MEMOIR 284

YUKON TERRITORY

Compiled and Annotated
by
H. S. BOSTOCK

GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS
OTTAWA
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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA
MEMOIR 284

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Selected Field Reports of the Geological Survey of Canada 1898 to 1933

Compiled and Annotated
by
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NOTE: For detailed topographic information the reader is referred to the new standard maps issued by the Surveys and Mapping Branch of the Department of Mines and Technical Surveys. Maps on a scale of either 1:250,000 or 1 inch to 4 miles are available for much of the Yukon and, for a few parts, on scales of 1:50,000 or 1 inch to 1 mile.

Although in general the original names are retained on the new maps, in a few instances new names have been substituted. For instance, the name Yukon River is now applied to the entire course of the main stream to its head above Whitehorse whereas earlier maps and reports called the part above the junction with Pelly River, Lewes River.

PREFACE

This compilation of Yukon Territory reports has been prepared in response to a continuing and increasing demand for information contained in early, out-of-print accounts of the Territory. Such information is not now readily available to the mining industry or to modern scientific libraries and educational institutions. Much of this compilation deals with early geological explorations, some in regions not since visited and but little known to the public. In part, too, it includes accounts at first hand of the initial operations in mining camps or on properties where much work was being done and in which continuous or intermittent interest has since been maintained. Here, for example, are reprinted the original accounts of the Klondike placer fields, the Whitehorse copper belt, the Windy Arm and Wheaton River silver and antimony ores, the Mayo and Beaver River silver-lead camps, the Carmacks coal deposits and many other districts and areas where indications of mineral wealth have been explored. These accounts form an enlightening historical background to more recent mining operations in the same or neighbouring areas that are becoming increasingly known through modern transportation facilities and reconnaissance surveys.

The volume covers the period from 1876 to 1933 inclusive, and is arranged chronologically with an introductory note or notes summarizing the field work accomplished each year and followed, in most instances, by complete texts of the published reports for that year. Page numbers of the original reports are indicated in the Contents pages and introductory notes of this report.

None of the original maps is reproduced with this compilation, partly because of the cost involved and partly because most of them have been superseded by more recent maps. The accompanying geological map of Yukon Territory includes essentially all known geological information and is prepared on a modern base on which the names of the main geographical features referred to in the volume appear.

GEORGE HANSON,
Director, Geological Survey of Canada

OTTAWA, 1956

YUKON TERRITORY

Summary for 1876-97

The first reference in publications of the Geological Survey of Canada to the geology and minerals of Yukon is made in Dr. G. M. Dawson's *General Notes on the Mines and Minerals of Economic Value of British Columbia, with a List of Localities*, published in 1878 in the *Report of Progress for 1876-77*. On page 140, Dawson supplies notes on the reported discovery of placer gold on "Sayyea Creek", "DeLiard River" and "Rapid River", and advances the view that the geological and mineral belts found to that date in British Columbia and the western United States would continue north-west into the unexplored areas of the north. In the Annual Report for 1886, part R, Dawson presents the data available at that time on the Arctic Coast west of Mackenzie River.

Geological field work began in Yukon with the "Yukon Expedition of 1887-88" of the Department of the Interior, which was organized under the leadership of Dawson, and comprised three parties, headed by G. M. Dawson and R. G. McConnell of the Geological Survey and William Ogilvie of the Dominion Land Survey. The three parties left Victoria together on May 12, 1887. Dawson and McConnell parted company with Ogilvie at Wrangell, and commenced their journey up Stikine River. Ogilvie continued up the coast to the head of Lynn Canal. From there he traversed over the Chilkoot Pass and down Lewes and Yukon Rivers to the International Boundary at the 141st Meridian. On the way he met Dawson at the mouth of Pelly River, in August. Ogilvie wintered at the Boundary, and after establishing its position, crossed from Yukon River to the head of the Porcupine in the spring of 1888. He descended the Porcupine to Bell River, and traversed up the Bell and over Richardson Mountains to Fort McPherson, near which place he met McConnell on his way to Yukon River, on the evening of June 23. Ogilvie then ascended Mackenzie River and returned to Ottawa.

Dawson and McConnell ascended Stikine River and crossed the continental divide to the mouth of Dease River, where they separated. Dawson followed the upper Liard and Frances Rivers, crossed the divide again to Pelly River, and descended it to meet Ogilvie at its mouth. From there Dawson returned up Lewes River and over Chilkoot Pass to Lynn Canal by the route Ogilvie had used, reaching the sea on September 20, 1887.

McConnell, on parting with Dawson at the mouth of Dease River, explored the lower Liard and Mackenzie Rivers and the west end of Great Slave Lake. He wintered at Fort Providence at the west end of Great Slave Lake. In the following spring, he descended the Mackenzie to its junction with Peel River at the head of the Mackenzie delta, and visited with Ogilvie at Fort McPherson on the Peel. He then crossed Richardson Mountains to Porcupine River and followed that stream down to Fort Yukon in Alaska. From there he ascended Yukon and Lewes Rivers, and crossed the divide to Lynn Canal, following the same route as Dawson and Ogilvie, and reached tidewater within a few days of a year later than Dawson.

The results of the threefold expedition have been published in different reports, Dawson's account, the first printed, appearing as part B of the Annual Report of the Geological Survey of Canada for 1887; McConnell's, part D of the Annual Report for 1888-89; and Ogilvie's as part 8 of the Annual Report of the Department of the Interior for the year 1889.

With the discovery, in August 1896, of the rich Klondike gold placer field, the demand for information on the Yukon was so great that before the close of 1897 the supply of reports and maps of the "Yukon Expedition of 1887-88" was exhausted, and Dawson's report of 1887, together with the parts of McConnell's report of 1888 that related to Yukon, was reprinted as publication No. 629 of the Geological Survey of Canada. This report carries the same title as Dawson's original report, of which it is an exact copy except for the omission of the appendices and the addition of part of McConnell's report. A considerable stock of this reprint with its maps is still available.

Most of the territory traversed by the parties of this expedition are shown on the new geological map of Yukon (Map No. 1048A) and British Columbia (Map No. 932A). The reports of this expedition remain the only source of authentic geological information for much of northern and south-eastern Yukon.

No further field work was done in Yukon until 1898, when the territory was visited by J. B. Tyrrell and R. G. McConnell. Since then, with the exception of 1910, the Geological Survey of Canada has maintained at least one party in Yukon each year. The early reports were published in the Annual Reports (New series) of the Geological Survey of Canada, and also issued separately. Later, in 1905, reports were issued in the annual Summary Reports of the Geological Survey, and, from 1917 to 1933 inclusive, in separate parts of these Summaries together with reports on areas in British Columbia. Since 1904 many separate publications have been issued, including twenty memoirs dealing in part with specific map-areas and in part with the mining industry of the territory. Most of these publications are still available.

1898

Introductory Note

Geological Survey field parties commenced work annually in Yukon in 1898. An account of investigations for the first year is contained in the Summary Report for 1898. In the Director's letter, which introduces the work of his field officers, Dr. Dawson writes (p. 24A):

"To Mr. J. B. Tyrrell was assigned the preliminary examination of a portion of the Yukon district, to the west of the line of the Lewes River and south of Fort Selkirk. Considerable difficulty was experienced in this work, on account of the failure of the horses depended upon for transport, but about 300 miles of new surveys were made and geological and other facts noted respecting the vicinity of the Dalton trail which had previously been mapped by McArthur of the Dominion Land Survey. Mr. Tyrrell also joins with Mr. McConnell in a short report, giving the results of their united observations on the actual mode of occurrence and methods of working the gold placers of the Klondike region.

"To R. G. McConnell was entrusted the task of making a geological reconnaissance and exploration of part of the Yukon district to the east of the Lewes and south of the latitude of Fort Selkirk, together with the line of route from Teslin Lake to Stikine River in the northern part of British Columbia. He was also requested to make, if possible, a preliminary study of the mode of occurrence of gold in the Klondike region itself, where such important mining operations are already in progress. In the course of these operations the Big Salmon and Nisutlin Rivers were ascended to their sources, and surveyed wherever necessary, and Teslin River and the borders of Teslin Lake were examined. The results indicate the existence of several new tracts of country which appear to warrant close examination on the part of prospectors, besides affording approximate outlines for the geological formations over a large region in which these had previously remained unknown."

Tyrrell's report then begins on page 37A, followed directly by that of McConnell on page 46A.

DALTON TRAIL, FROM HAINES, ALASKA, TO CARMACKS, ON LEWES RIVER, AND EXPLORATION OF NISLING RIVER

by J. B. Tyrrell

On the 9th of May I received from you instructions for the season's work in the field, of which the material part was as follows:

"The principal object of your exploration will be to obtain as much geological and general information as possible respecting that part of the Yukon district between the line of the Lewes River and the 141st meridian, and to the south of the latitude of Fort Selkirk. The so-called Dalton trail will probably prove to be your most convenient base of operations, more particularly as it has already been mapped with some accuracy by Mr. McArthur of the Dominion Lands Survey.

"Should good geological sections be met with, it may be well to devote some time to their particular examination, but, generally speaking, the work will require to be of a reconnaissance character, with the main purpose of ascertaining in what parts of the region the formations and conditions are such as to encourage search for payable gold deposits, ores and coal. Information of this nature will undoubtedly possess great value in directing the operations of prospectors in the season of 1899, by which time entrance to the entire Yukon District will probably have become comparatively easy.

"The glacial and other superficial deposits will not escape your attention as these are likely to have intimate relations to the occurrence of placer gold.

"If found to be convenient, at some time during the season it might be advisable to pay a brief visit to the Klondike region, for the purpose of comparing conditions there with those in the region more particularly under examination; but it would be unwise to allow this to materially interrupt the main work, in view of the shortness of the season, the necessary cost of the outfit for the expedition, and the probability that the horses, etc., may not be available for further operations in a following year. The same circumstances will render it proper to continue work in the autumn as late as the conditions remain reasonably favourable."

J. J. McArthur, D.L.S., of the Topographical Branch of the Department of the Interior, had travelled over part of the Dalton trail last year, and was going over it again this year on his way to Stewart River. He kindly offered to purchase horses for me and to take them to Pyramid Harbour with his own; as he was acquainted with the district, and where feed, if any, could be obtained, this was a favour which would assist me very materially at the beginning of the exploration.

J. F. Shaw, of Ottawa, was employed to look after the horses, and on the 26th of April I sent him west to join Mr. McArthur in Vancouver, with instructions to render any assistance in his power in the purchase and care of the horses. On the 12th of May I left Ottawa and proceeded to Kamloops, where I obtained some saddles and blankets belonging to the Survey that had been stored there some years before.

Thence I went to Vernon, and there employed two men, Cameron and Redmond, the former as packer, and the latter as cook. With these men I went to Vancouver, where I found that Mr. McArthur had gone on with the horses on the steamer *Islander* a few days before. After obtaining the supplies necessary for the summer, we followed in the steamer *City of Seattle*, and on 28th May arrived at Mr. McArthur's camp on the bank of the Chilkat River, not far from Haines Mission. As yet the grass had scarcely began to grow, and the country afforded very little feed for the horses, so that it was necessary to supply them with feed brought from the south. Dalton's new trail was not yet cut out on the west side of the river, and the flats by the river were so wet that they were scarcely passable.

Mr. McArthur obligingly agreed to continue in charge of both parties until the 12th of June, during which time he was able to move about twenty-five miles up the Chilkat River to the crossing of Salmon River. From here he was obliged to return to Dyea, while I pushed on to the camp of the North-west Mounted Police at Pleasant Camp, and then over the summit to Rainy Hollow, being the first to reach there with horses this summer. At the Mounted Police station, Inspector Jarvis kindly had all our horses shod, for many of them had dropped their shoes among the stones in the beds of the streams that had been followed or crossed. Our party, on leaving

Pleasant Camp, consisted of myself, three men, and fourteen horses. On account of the scarcity of food the horses had failed in flesh very considerably.

The hill just west of Pleasant Camp, forming the high land known as "The Summit", is a spur of gray hornblende-granite projecting out into the valley. It is 1700 feet in height and rises with a slope of 22° from a small grassy plain surrounded by dense coniferous forest, to a barren alpine plateau, entirely devoid of trees. The luxuriant flora of the Pacific Slope extends up the Klaehini valley to this hill, and to some extent around it, and up the valley to Rainy Hollow, but beyond that point the flora of the drier interior plateau takes its place.

We continued on to Dalton post, on the Tatshenshini River, where we arrived on June 24th. The Indians of the surrounding country were collected in the adjacent village of Wesketahin to await the arrival of the salmon up the stream.

On the way, I had made as careful an examination as possible of the general geology of the region, but since the sides of the wide valley were covered with glacial detritus up to height of from two to three thousand feet, it often required the expenditure of a great amount of time to see the underlying rock at all. As a general rule, however, the valley was found to run between a range of granite mountains to the north-east, and a range of mountains of schist, quartzite, etc., to the south-west.

The main branch of the valley, which we had been following, continues on towards the north-west from Dalton post, but we turned northward up the valley of Unahini River, and followed the banks of this stream, or climbed along the slopes of the mountains, to Klukshu Lake. Here a trail turns westward towards Shorty, Roberts and Alder creeks, but the Dalton trail, which we were following, continued northward, up the east side of the lake, and then across the wide Shakwak valley, through which Messrs. Glave and Dalton first reached this country in 1890. Lake Dezadeash lies in the angle where the two valleys cross, and from it flows one of the longest branches of the Alsek, at first northward, then westward and afterwards southward to the Pacific. After leaving Lake Dezadeash it flows through a deep and comparatively narrow valley, between Mount Kelvin, a magnificent granite mass that rises to a height of 5000 feet above the river on the east, and Mount Bratnober, about a thousand feet lower, on the west; this latter mountain appearing to be composed chiefly of dark mica-schists. Near Hutshi, the sources of the Nordenskiöld River, one of the tributaries of the Yukon, were reached. Up to this time no attempt at a survey had been made, but at Mr. McArthur's request I had taken a few observations for latitude.

At Hutshi I began a compass and paced survey of the trail down the Nordenskiöld River, and continued this survey down to the Lewes River, where we arrived on July 12th.

Although the greatest possible care had been taken of the horses they were now very much run down. I therefore left them here in charge of the men and in good pasture, and descended the river to Dawson, where I arrived on the 16th of July. Mr. McConnell, of this Department, had arrived there the day before, and together we examined Bonanza, Eldorado and part of Dominion creeks. Our report on this work is given on another page.

On the 7th of August, I again reached my camp at the mouth of the Nordenskiöld River, but unfortunately some inflammatory disease had broken out among all the horses there, Mr. Dalton's as well as mine, and instead of being in good condition for the work of the rest of the season they were lean and weak.

At Dawson Mr. S. N. C. Treadgold, who was visiting the country in the capacity of a special correspondent of the *Mining Journal*, offered to accompany me for the rest of the season, and being rather short of men I was glad to avail myself of his services.

Acting on a suggestion made by Mr. McArthur, we returned up the Nordenskiöld River for a short distance, and then turned westward up the west branch of that stream, for which I would suggest the name Wright River, after Professor R. Ramsay Wright of Toronto University. We ascended the valley of this stream for most of its length, and then turned south-westward, through a ridge of rounded granite mountains, to a valley in which is a stream flowing towards the west. This valley was descended to the point where it is crossed by a trail from Hutshi to Fort Selkirk, and here the stream was recognized as that which had been called the Tahté by Mr. McArthur. We then travelled south to the Indian village of Aishihik, hoping to meet some Indians who would indicate to us the most feasible route into the country further west, but the place was found to be entirely deserted, so that we were thrown back on our own resources.

Finding a foot-trail leading to the west, we decided to follow it. It led us into a mountainous country underlain by mica-schist, limestone, etc. The second day we came to a creek flowing westward, but after following it, it turned to the north, and three days afterwards brought us to a wide valley which was evidently that of the Tahté River, and not far from the place where we had left that river a week before.

We descended this magnificent wide valley, which has finely terraced sides, for five days, until we found it opening out into the valley of White River*. We thus found that the stream which we had been following was the Nisling River, which had been crossed by Dr. Hayes in 1889, on his overland journey from Fort Selkirk to the Copper River.

It was now the 29th of August, and a hard frost on the night of the 27th had begun to strip the leaves from the poplars, warning us that the summer was over, and that the Chilkat Mountains, near the coast, would soon be covered with snow. We therefore turned back up the Nisling River, followed it up to the crossing of the Selkirk trail, and then followed that trail southward to Aishihik. From Aishihik we followed the high ridge west of Aishihik Lake, crossed the Aishihik River, and reached the west side of Hutshi Lake, just as Mr. Hanley camped on its eastern side with a large band of horses.

The next morning, Sept. 12, we came up with Mr. Hanley, and as most of the horses that we had left were about used up, we hired three fresh ones to help us out to Pyramid Harbour. On September 17th, we reached Dalton post, and on the 21st the post of the North-west Mounted Police at Pleasant Camp. Besides the horses that we had hired from Mr. Hanley, there were six of our own remaining. We had spared them all summer as much as possible, by carrying just what was absolutely necessary for the work in hand, and by walking almost all the time ourselves, but the change in their conditions of life from southern British Columbia to the Yukon district, had proved too much for them, and they had dropped off one by

* In 1898 it was not known where Donjek River entered White River, and here, judging by C. W. Hayes' map, which was incorrect on this point, Tyrrell thought Nisling River ran into White River, and mistook Donjek River for the White. (H.S.B., 1956.)

one. Three of the six could go no farther, and Inspector Jarvis kindly loaned us three others in their place to take us down to the coast. Pyramid Harbour was reached on September 25th, Skagway on the 26th, and Ottawa on the 13th of October.

During the season, from the time of leaving Pyramid Harbour until my return to the same place, I travelled about 1300 miles. A geological examination of the country was made throughout most of this distance, and new surveys were made aggregating 300 miles in length. A large number of photographs were also taken, showing the general character of the country traversed, the appearance of the rocks underlying the country, the gravel terraces, the hill and valley gold-claims, the mode of sinking shafts, of making open cuttings, of rocking and sluicing gold, etc.

Fifty-one species of plants were collected, and these have since been determined by Mr. J. M. Macoun. Of these (1) *Parrya macrocarpa*, (2) *Phlox Richardsonii*, and (3) *Gentiana frigida* had not before been found in the Yukon district, and the last-named not before in any part of Canada. The localities at which they were found were, respectively: (1) summit of Father Mountain, about 6000 feet, (2) Selkirk Trail, and (3) tributary of Nisling River, above the tree-line.

The Dalton Trail and its Vicinity

The country in the vicinity of the Dalton trail, may be divided into two parts, with topographical characters sufficiently distinct and persistent to be almost everywhere recognizable, viz.:—The Chilkat Ranges, a name here proposed for the high range of mountains extending north-westward and westward from the Lynn Canal and the table-land of the interior.

The Chilkat Mountains form a rough irregular range, extending inland for about a hundred miles from the main coast-line of the Pacific Ocean, which coast-line stretches south-eastward from Yakutat Bay to Cross Sound, and thence onward along the outer side of the Alaskan Archipelago.

In the district at present under consideration, which lies north-west of the head of Lynn Canal, these mountains form an elevated region whose outer side descends more or less steeply towards the ocean, while many jagged, rocky peaks rise to heights of 6000 to 8000 feet above the sea.

The mountains are intersected by deep valleys, of which the higher parts, lying at some distance back from the coast, are for the most part filled with vast fields of snow and ice, from which glaciers radiate in all directions, some descending steeply towards the coast, while others move landwards and give rise to some of the largest streams draining the country, notably to White River, and to many of the tributaries of Alsek River. The ice has, however, withdrawn or melted away from some of the valleys, and has left their sides with beautiful smooth well-rounded slopes. Of these ice-free valleys, none is more conspicuous or persistent than that which, in its outer coastal portion, is drained by the Chilkat and Klehini rivers; while farther inland its waters are collected into the Tatshenshini, or most easterly branch of the Alsek River.

In this valley, the Chilkat Indians of the village of Klukwan, and of the other villages on the banks of the Chilkat River, have for ages had a foot-path by which they travelled between the coast and the interior, in order to trade with the more remote tribes living on the upper waters of the Alsek River. This path has been cut out and improved by Mr. J. Dalton, until there is now an excellent trail for pack-horses from the coast into the interior, appropriately known as the Dalton trail.

This trail follows the above-mentioned valley from Pyramid Harbour to Klukshu Lake, a distance of about 120 miles, running in a general northwesterly direction diagonally through the Chilkat Mountains. In this valley the height of land, which is at a distance of seventy miles from Pyramid Harbour, has an approximate elevation of 2650 feet above the sea, being more than 200 feet lower than the summit of the White Pass, and 850 feet lower than the summit of the Chilkoot Pass, while at the same time, being more distant from the coast, the approach to it is much more gradual.

The height of land, or water-parting, is hardly recognizable as such, being only a wide, flat, swampy portion of the bottom of the valley. Beyond it, the valley declines gradually north-westward, with a slope of about twenty-five feet to a mile, without any abrupt break or dip of any kind. Its bottom varies from half a mile to a mile or more in width, and its sides rise in gentle grassy slopes and terraces for a couple of thousand feet, above which tower mural precipices, and broken rocky cliffs.

For about fifty miles from Pyramid Harbour, the valley is everywhere, except on the flooded land besides the streams, wooded with a dense coniferous forest; but on the upland country, for the next fifty miles, very little timber is anywhere to be seen, the lower lands and the mountain sides being alike covered with short grass, or a dense growth of dwarf birch and willow.

The interior table-land is also a decidedly mountainous country, but the slopes are more gradual. Most of the peaks are gently rounded, and there are no glaciers or permanent snow-fields, so that while a great number of peaks may be in view at one time, and though these peaks may in some cases rise as high as from three to four thousand feet above the bottoms of the adjoining and intervening valleys, the whole landscape has the appearance of a hilly or lumpy upland, the higher portions covered with grass or scrub, while groves of dark, green spruce may partly cover the bottomlands. In many places, level terraces follow along the sides of the mountains, forming wide and easy steps, which are usually thinly wooded with poplar, or covered by a rich grassy turf. These dry, thinly wooded terraces, and in fact much of this inland region, reminds one strongly of parts of the attractive country near the banks of the Saskatchewan River, east of the Rocky Mountains.

The wide valley mentioned above, continues northward through this interior table-land. North of Dalton post, it is drained by the Unahini River, beyond which lies Lake Dezadeash, and that branch of the Alsek River which flows from it. From the north* bend of the Alsek, one branch of it continues across to the Mendenhall, and thence down the Nordenskiöld to the Lewes, but another branch would appear to turn northward* down the Alsek, then northward up the Aishihik River to Aishihik Lake, over Aishihik Lake, and along the wide flat valley north of it to Nisling River, down Nisling River to White River, and down White River to the Yukon River; having a remarkably direct course throughout the whole distance. This valley, whether entered at Pyramid Harbour, or at some point which may be easily reached by the White Pass, is undoubtedly the shortest and

* It is apparent from the script and maps, that these two words should be 'west' and 'westward' respectively. (H.S.B., 1956.)

easiest known route from the coast to the heart of the gold district of the Klondike.

Many natural fruits common east of the mountains, here grow and ripen in great profusion, and it seems not at all impossible that most, if not all, the grains, fruits and vegetables that will ripen in the Edmonton country will also ripen along this portion of the Dalton trail.

Wild animals, as a rule, are rather scarce, but one small mammal proved to be of more than ordinary interest. This was a ground-squirrel (*Spermophilus empitra*), which was very common on the terraces, everywhere from Rainy Hollow north to Rink or Five Finger Rapids, its burrows being conspicuous on all the dry places. In these burrows the animals live and continue active both in summer and winter, and in order that they may be warm and comfortable, the burrows invariably descend below the limit of frost. Consequently, wherever they are found, the frost cannot be more than a few feet deep, or such a depth as the ground would freeze in winter and thaw again in summer. Now where the ground is permanently frozen the frost extends to great depths, and therefore, wherever these ground-squirrels can burrow and live the ground is not permanently frozen. On all the dry benches and uplands, as far north as Rink at all events, there is no permanently frozen ground, although many of the boggy places, whether in the bottoms or on the sides of the valleys, are certainly underlain by frozen ground throughout the year. The fact that these benches are not permanently frozen, removes one of the strongest objections that has been raised to successful hydraulic mining in the Yukon District.

The rocks observed in the southwestern portion of the Yukon district, range in age from the Archæan up through the Palæozoic, Mesozoic and Tertiary to Pleistocene sands and gravels, and in character they include granite, diorite, porphyry, porphyrite, diabase, trachite, rhyolite, basalt, lava, volcanic ash, mica-schist, sericite-schist, argillite, marble, quartzite, conglomerate, sandstone, etc., the last seven being more or less altered aqueous sediments which had been deposited one above another in the seas of the different geological epochs.

A massive gray and reddish-gray granite forms the main structural axis of this country, extending as it does north-westward from the head of Lynn Canal, past Lake Dezadeash, and away to the westward of Aishihik Lake. This is doubtless a continuation northward of the granite of the Coast Range of British Columbia, and like it is very barren of minerals of economic value.

Resting on or against the granite, and often very much disturbed and altered by it, is a dark argillite, interstratified with heavy beds of white crystalline limestone. In many places the argillite passes below into a highly crystalline mica-schist. These schists and argillites are usually cut by veins and stringers of quartz. Wherever they underlie the country, gold can usually be washed out of the sand in the bottoms of the valleys. Thus they appear to be everywhere, to some slight extent at least, impregnated with gold. They are very widely distributed, extending from the west side of Lynn Canal up the west side of the Chilkat and Klehini rivers, along the north-west side of Tatshenshini River, through the Dalton Range, and northward, past Aishihik Lake to the Nisling or Tahté River, beyond which they are probably continuous with the schists that outcrop along the banks of the Yukon, from the mouth of Selwyn River to Dawson.

One of the most conspicuous and wide-spread rocks in the district, is a dark-green porphyrite, which has broken through and altered the argillites and limestones above mentioned. It composes the mass of many of the highest and most conspicuous mountains in this portion of the interior, among which are mounts Maloney and Fairview, while the Sifton Mountains are said to consist largely of the same material.

North-eastward, as far down the Lewes River as Rink Rapids, the country has been more or less severely glaciated, by an ice-sheet that extended inwards from the high ranges bordering its coast. This ice-sheet pared down many of the inequalities of the surface, and deposited a thick coating of unstratified boulder-studded clay or till in the bottoms of the valleys. Where the till has been chiefly derived from the argillites or mica-schists, as in parts of the valley of the Kaskawulsh River, it appears to contain a small amount of fine gold, some of which may eventually be recovered by inexpensive hydraulic processes.

Terraces of stratified clay, sand or gravel are common on the sides of some of the valleys, where they have been formed in lakes that existed at the foot of the great ice-sheet, or by streams that flowed from it. Some of these contain gold, where the deposits composing them have been derived from argillites or mica-schists.

Specimens of coarse gold were shown to the writer as having been taken from Alder Creek and other streams in its vicinity. The country-rock is reported to be an argillite or mica-schist, and the gold has doubtless been derived from it. Whether it occurs in large quantities or not is as yet uncertain, but the question is deserving of further investigation.

For some years past, it has been reported that native copper was to be found on some of the upper tributaries of White River. An effort was made to visit the locality, but the condition of our horses, rendered our progress through the country very slow and thwarted this object, though we reached the valley of White (Donjek) River at the mouth of Nisling River. Here some Indians whom we met, and who had some small masses of native copper in their possession, reported that the copper country was still six days' journey distant, and that the copper was invariably picked up in the gravel on the stony flats beside the stream. This report of its mode of occurrence agrees closely with other accounts which were received. Its occurrence *in situ* is not yet known, but quite probably it is associated with a basic igneous rock such as the porphyrite mentioned above.

Early in the year, fragments of copper-pyrites were observed among the gravel-wash from a glacier, a short distance south of Glacier Camp. On my return in the autumn to the camp of the Mounted Police at Pleasant Camp, I was shown some fine specimens of bornite and chalcopyrite, with galena, which were said to have been found near Rainy Hollow. These discoveries would appear to indicate the existence of deposits of native copper or copper ore which may, in the near future, be of great economic importance.

After his return from the field in 1897, Mr. R. G. McConnell was employed during the greater part of the winter and spring in working up the notes and collections made by him and his assistants in West Kootenay. When it was determined to undertake explorations in the Yukon District, part of which he had previously traversed in 1887, he was assigned to this work. His instructions were to make a geological reconnaissance by the chief eastern tributaries of the Lewes River and of the country adjacent to these, as well as a preliminary examination of the geological features of the route between Teslin Lake and the Stikine. He was also to devote a portion of the season to a general inspection of the geological conditions on the richly auriferous creeks of the Klondike region. All the main objects thus outlined were successfully covered during the rather short available season. The results are given as follows by Mr. McConnell.

BIG SALMON RIVER, TESLIN RIVER AND LAKE, NISUTLIN RIVER, AND ROUTE FROM TESLIN LAKE TO TELEGRAPH CREEK

by R. G. McConnell

I left Ottawa on May 13th for the Yukon district, accompanied by two Indians from Lake Temiscaming, who acted as boat-men and proved to be both capable and trustworthy. We reached Vancouver on May 19th and Dyea on May 27th. Our outfit, consisting of four months' supplies for three men, a Peterborough canoe and a canvas boat, was taken across the Chilkoot Pass from Dyea and landed at the head of Lake Bennett by the Chilkoot N. & T. Co. in three days. The ice on the lake broke up in the first week in June, and we were able to proceed immediately down the river. We left, the head of Lake Bennett carrying our outfit in the canoe and canvas boat, and reached the mouth of the Big Salmon without accident on June 12th. From this point a traverse and geological examination was made up the Big Salmon to the head of Quiet Lake.

The Big Salmon has an approximate length of 142 miles, to the chain of lakes at its head, or, including the latter, a length of about 170 miles. Its width varies from thirty to a hundred yards. In a few reaches, it is a smooth, placid stream with an easy current, but for most of its length it is shallow and rapid, interrupted by numerous sand-bars and gravel-bars, over some of which the river has a fall of several feet. Rapids occur at the mouth of the North Fork and at another point about seventy miles further up, but can be easily run by small boats, except at low water. The Big Salmon cannot be considered a navigable stream for steamers, even at high water, and at low water small boats, when loaded, find difficulty in navigating it.

For forty-five miles above its mouth, the Big Salmon occupies a wide wooded valley bordered by rounded hills. Above that point it turns to the east and enters a wide range of mountains, through which its valley runs from its source in Quiet Lake. The direction of the river for the first thirty or forty miles above the South Fork, is generally transverse to that of the mountain ranges, but is parallel to them further up. The valley becomes much narrower after the mountains are entered, being in some places reduced to a width of less than a third of a mile, and is bordered by steep-sided mountains and mountain ranges from 3000 to 4000 feet in height above it, on some of which patches of snow exist in sheltered nooks throughout the year. It is terraced up to heights of from two to four hundred feet along its entire course.

The main tributaries of the Salmon are the North Fork, entering about twenty-five miles above its mouth, the South Fork, which comes about twenty miles further up, and a stream which joins it from the east a short distance below the lake. Besides these a number of large streams, heading in the adjoining mountain ranges, join it at various points along its course.

The Salmon River heads in a chain of lakes about twenty-eight miles in length, connected by short streams with little current. The highest lake is the largest and is known as Quiet Lake. It is about nineteen miles in length with a maximum width of two and a half miles. The depth was not measured, but the lower, or Island Lake, gave a maximum sounding of 138 feet. Quiet Lake is bordered on the west by high mountains, and on the east by a rolling plain that extends to the Nisutlin River, four to five miles distant, and is broken by a number of rocky hills, the highest of which rises 1900 feet above it. The valleys of the Salmon and the Nisutlin are united at the upper end of Quiet Lake and also at Island Lake. The longer diameter of the latter is transverse to the general direction of the rivers, and follows an old valley connecting the two streams, now filled up with glacial deposits.

The valley of the Salmon is generally fairly well forested along the bottoms and up the mountain slopes to heights of from 1500 to 2000 feet above the river. The principal forest trees are the white and black spruce, the former often attaining a diameter of a foot or more, the black pine, a variety of fir, birch, aspen and balsam poplar.

The Salmon River valley, except for the first forty miles, affords a very good geological section. Below the North Fork, the valley is wide and exposures are infrequent. The rocks seen consist of greenish tufaceous sandstones, passing into agglomerates and slates, cut by diabases, and a whitish porphyritic rock of geologically recent appearance. At the North Fork, a range of hills four miles east of the Salmon consists of reddish medium grained granites, and the same rock is reported to occur eastward along this stream for a number of miles. Between the North and South forks, no outcrops were noticed. Above the South Fork, the valley enters the mountains, becomes narrower, and exposures are frequent. The rocks above the South Fork consist of micaceous schists, quartzites, greenish schists and limestones, cut by granitic dykes. The dips are vertical or to the west. The green schists and associated rocks are succeeded, in going up the river, by a wide band of dark slates and schists interbanded with green schists, and further on by whitish granular limestones. The limestones are cut by a wide band of grayish granite. They dip to the east, except near the granite, where they are vertical, and are underlain by a great thickness of quartzite and micaceous schists alternating with bands of crystalline limestone. These rocks resemble the Shuswap series of the Selkirk Range. They are bent up into a great anticline, and are exposed, with little variety in composition, for many miles along the valley. The axis of the anticline crosses the Salmon near a great bend which the latter makes to the north. Above that point the dips are to the east. The Shuswap schists are overlain about forty miles below the lakes, by a limestone band similar to that which occurs in the western limb of the anticline. The limestone is exposed along the river for some miles and forms conspicuous mountain ranges on both sides of the valley. It is succeeded, in ascending the river, by dark slates and schists holding bands of greenish tufaceous beds and some limestones. The tuffs in places have been altered into serpentines. The slates and associated green schists are exposed along the Salmon to the lakes and along the lakes to a point about half way up Quiet Lake, where they are cut off by a great granite area which can be traced southward along the Nisutlin River to Teslin Lake.

The rocks of the Salmon River anticline consist, in a general way, of three great divisions. A basal series of quartzitic and micaceous schists and crystalline limestones, an intermediate granular limestone, and an upper division consisting of dark slates, green schists, tuffs, limestones and serpentines. No fossils were found and it is impossible to fix the age of these formations with any certainty.

A number of prospectors ascended the Salmon during the summer, but most of them were inexperienced, and little effective work was done. Several shafts were commenced, but the influx of water prevented deep sinking, and none of them reached bed-rock. Fine gold is found all along the Salmon, and a number of the bars below the North Fork have been worked successfully during low water in former years. Coarse gold was stated to have been found in a couple of places in the lower part of the river, but I was unable to verify the reports. Fine colours were obtained in the wash of many of the streams emptying into the Salmon, and on a bar at the mouth of the stream which joins the latter three to four miles below the lakes, a very good prospect was obtained. Small quartz veins cut the schists in a number of places, and at one point west of Island Lake, several large veins cutting a dolomite band were noticed. Specimens of this quartz were collected but have not yet been assayed. An angular fragment of drift quartz, holding gold, was found at the mouth of a stream about twenty miles below the lake. The country in the neighbourhood of the upper part of the Salmon, based as it is on old schists cut by great eruptive masses, offers a very favourable field for prospecting, both for quartz and placer gold. It was run over by a number of people during the past summer, most of whom, however, had little knowledge of any branch of mining, and very little genuine prospecting was carried out.

After finishing the examination of the Salmon, I went down the Yukon to Dawson, and spent two weeks in a hasty examination of a part of the Klondike region, some notes on which are given in another part of this report. From Dawson I came up the Yukon in a steamer to the mouth of the Salmon, and spent the remainder of the season on Teslin River, Teslin Lake, the Nisutlin River and the Teslin trail.

The Teslin or Hootalinqua River is one of the main feeders of the Yukon. It is a large stream, averaging about 125 yards in width when confined, but widening out around islands, and with a length, according to Mr. St. Cyr's survey of 1897, of about 100 miles. The current is pretty swift for the first seventy miles, running from three to five miles per hour, with occasional accelerations where bars cross the stream. Thirty miles below the lake, the grade lessens and the current drops to less than two miles an hour. No rapids occur on the Teslin, but bars are frequent and on some of these the water in the autumn is so shallow as to interfere with navigation. The steamer *Anglian* which was built on Teslin Lake, descended without much difficulty in the early summer, but was unable to ascend again towards the end of August, on account of the shallowness of the water on the bars. The Teslin differs altogether in character from the Lewes. The latter is fed largely from the glaciers of the Coast Ranges and remains fairly high until the cold weather sets in. The Teslin, on the other hand, has no such reserves to draw upon. It rises in May with the melting of the snows, is in full flood about the first week in June, and then falls steadily, as the lakes are gradually emptied, throughout the season. The summer of 1898 was an exceptionally dry one, and it is claimed that the Teslin was lower than usual on this account, and that in ordinary seasons its navigation is practicable until late in the autumn. This is quite possible, but as no good records for preceding years exist it is still an open question.

The valley of the Teslin averages about a mile in width, from the mouth up to within a few miles of the lake, where it widens out to about two miles. It is bordered by high lumpy hills and low mountain ranges throughout its whole length. Between the river and the base of the hills, is a series of flats, the highest of which has a remarkably uniform elevation all along the river of from 300 to 320 feet. The immediate banks of the river are generally terraced, but high cut-banks of white and light-yellowish silts and boulder-clay occur at the elbows of some of the bends.

The geological section along the Teslin is not very satisfactory, as the course of the river is almost parallel to the strike of the rocks. Near the mouth, and for some miles up the river, a recent volcanic rock outcrops, the character of which has not been determined. It incloses fragments of slate and is succeeded by a band of crushed and altered slates. The slates are followed by reddish-weathering tuffs and agglomerates, and frequent exposures of these rocks, alternating with slates, appear along the river or on the hill-sides nearly all the way to the lake. They inclose occasional bands of nodular limestone. At the mouth of Boswell River, which enters the Teslin from the east, a conspicuous range of bold mountains is built almost entirely of grayish and reddish-weathering limestone. Above Boswell River, dark and greenish slates and schists, tuffs and other old volcanic fragmental rocks resume and continue to the head of the river.

Fine gold is found in a number of bars and beaches along the Teslin, but as a rule in inconsiderable quantities. Some work was done on a few of the bars during the past season, but the results were stated to be not very satisfactory. The streams entering the Teslin are few in number and with one or two exceptions insignificant in size, and as they do not as a rule traverse an especially promising gold country, it is probable that the gold in the Teslin gravels is largely derived, from the washing away and concentration, by the river, of the glacial and stream deposits which floor the valley.

The Nisutlin River was traced into the Pelly Mountains, and the branch followed was found to head within twenty miles of the Pelly River. The Nisutlin enters Teslin Lake about thirty miles above its lower end, and is its principal feeder. It has a width of from 200 to 400 feet. The current is swift to the first fork (Wolf River), a distance of about three miles, above which, for many miles it does not exceed two to three miles an hour. The river winds, in its lower reaches, through a low, alluvial plain, apparently a filled-up bay of the lake, which gradually narrows to the north. The valley is wide, often exceeding ten miles, and is bordered by low round-topped mountains rising from 3000 to 4000 feet above it. A wide forested plain spreads from the immediate valley of the river to the foot of the mountains. The river is crossed by numerous shallow sandy bars in this lower part, and by gravel bars further up where the current is swifter. The water on many of these was found to be too shallow to allow of the navigation of the river by steamers of any size, late in the season.

The Nisutlin valley has a nearly north-and-south direction from Teslin Lake to a point opposite Quiet Lake on Salmon River, a distance of about seventy-five miles. The valley still continues to the north above this point, and is occupied by a fork of the Nisutlin (Rose River), but the main river bends suddenly to the east and follows a north-easterly course through a wide range of mountains that extends north-eastward almost to the Pelly. The Nisutlin, after entering the mountains, becomes narrower and swifter, steep bars are frequent, and long bouldery rapids render its navigation, even with small boats, difficult and dangerous. We cached our canoe at the foot of one of these rapids and continued the exploration on foot.

About twenty-five miles from the point at which the mountains are entered, the river again forks. The main branch comes from the east and appears to head in a wide lake-dotted plain, a view of which was obtained from the summit of a high mountain at the forks. The route from the Liard leads down this branch. The left fork, which was the one followed, as it promised a better geological section, breaks through the range in a north-easterly direction. Above the forks just mentioned, the branch we ascended dwindles rapidly in size as numerous feeders from both sides are passed. About twenty miles from the forks we turned up a small stream flowing from the summit range, and five miles further on reached the Nisutlin-Pelly watershed. This was crossed by a good pass about 4000 feet above the sea, flanked by rugged mountains about 3000 feet higher. We continued on down a stream to the north, for about seven miles, and then returned. From the summit of a mountain opposite our last camp, the Pelly was seen flowing in a wide valley, at a distance of about twenty miles. The Pelly Range, where crossed, runs nearly east-and-west. South of the divide, it consists of a number of well-defined subordinate ranges striking east-and-west. North of the watershed, it has been carved into a confused mass of mountains and mountain groups by a number of branching streams tributary to the Pelly. Some of the peaks in the watershed and adjoining ranges exceed 7000 feet in height. The valley and lower slopes of the mountains are generally wholly or partially wooded up to a height of about 3000 feet above the sea. Above that point, grassed and moss-covered slopes and bare peaks and ridges prevail.

The Nisutlin River, until it leaves the main valley east of the Salmon lakes, does not afford a good geological section. The valley is wide, and the river is bordered by wide wooded flats composed of alluvial or glacial materials. Occasional traverses were made to the mountain ranges, on both sides, on the way up, and some data were collected, but the section is incomplete. Greenish volcanic rocks, usually more or less schistose, occur along Nisutlin Bay. At the head of the bay, a wide band of granite crosses the valley. In the lower reaches of the river, green schists outcrop in a few places along the valley, and then exposures cease. The mountains west of the valley are composed principally of grayish granite and form part of the great granite area, mentioned before, that stretches from Quiet Lake south, to, and along Teslin Lake. The granite crosses the valley and outcrops in the mountains east of the Nisutlin above the first fork, and extends north about half way to Quiet Lake. Above that point, green schists interbanded with limestone come in, and are exposed in the ridges east of the river for many miles to the north. Greenish schists, cut by granite dykes from the Quiet Lake granite area, also outcrop in some small hills on the portage from the Nisutlin River to Quiet Lake.

Above the point at which the Nisutlin bends to the north-east and cuts across the mountain ranges, exposures become more frequent. Green schists and dark slates, interbanded with some limestone or dolomite, outcrop for several miles, and are succeeded by a coarse-grained, reddish porphyritic granite which continues almost to the upper forks. Beyond the granite, green schists resume, and are succeeded by lead-coloured and black slates and schists and then by quartzites and dolomites. The dip is to the west and the section is a descending one. The quartzites and associated rocks are followed by a band of heavy limestone beds that forms a conspicuous range, and then by dark slates and schists, and green schists and limestones which continue to the summit of the Pelly Range. At the summit, the beds have an anticlined attitude. They consist there mostly of dark slates and schists, with some agglomerates, succeeded, on the north slope of the range, by green schists and limestones. A band of limestone three miles east of the summit contained some corals and fragments of other fossils which are probably of Carboniferous age. Old Cambrian schists such as occur on the upper part of the Big Salmon River, were not found on the Nisutlin, and the stratified rocks seem to belong mostly to the Upper Palæozoic, while some may even be of Mesozoic age.

Mining operations on the Nisutlin, so far, have been confined to prospecting. Fine gold occurs along it at various points, but up to the present has not been found in paying quantities. A great development of quartz veins occurs south of the summit on the branch ascended. The veins are small but exceedingly numerous. They occur mostly in the dark slates, and schists and greenish schists. Quartz boulders and pebbles form the principal constituents of the gravels in the streams flowing from the range. The streams and mountains in this vicinity seem well worth prospecting.

The shores of Teslin Lake were hastily examined on the way out. This lake was surveyed by Mr. St. Cyr, D.L.S., of the Dominion Lands Branch, in 1897. It is a long, narrow sheet of darkish water, from one to two miles wide, and with a length, according to survey, of about sixty miles. A line of soundings across the lake north of Dawson Peaks gave a maximum depth of 435 feet. The bottom of the lake, outside the steep shore-slope, is a nearly level plain covered by about 400 feet of water. The lake is almost completely encircled by medium-sized mountains and mountain ranges, the most prominent of which are the Dawson Peaks, known locally as the 'Three Aces' which are situated about half way up the lake, on the west shore, and have an elevation of 3800 feet above the lake. The mountains are separated from the shore of the lake by a wooded plain of varying width, and at Hall River a lake-sprinkled area of rolling country extends some distance to the south-west.

The rocks along Teslin Lake are very similar to those on the Nisutlin River. They consist of green schists, tuffs, agglomerates and limestones. Grayish granite, somewhat similar to the gray granite of the Kootenay country, occurs along the east shore of the lake, south of Nisutlin Bay, and a spur crosses the lake and is exposed opposite to and in the Dawson Peaks. Granite also comes in on the west shore of the lake two miles below the Narrows and extends south to near Hayes River. Above Hayes River, dark slaty rocks, tuffs and limestones resume, and continue to the head of the lake.

From the head of Teslin Lake we came out by the Teslin-Stikine trail to Telegraph Creek. This trail has a length of about 151 miles, and with the exception of about fifteen miles in the vicinity of Spruce Mountain, has been well graded and corduroyed throughout during the past summer, and is now in excellent condition. A partial examination was made of the rocks along the trail. From the head of Teslin Lake to the Naylin River, a distance of about fifty-seven miles, the beds consist of a succession of rusty-weathering, dark, slaty rocks, tuffs, green schists and grayish limestones. The Naylin River valley, at the trail-crossing, cuts into yellowish-weathering, soft sandstones of Tertiary age. Drift lignite occurs on the bars, but no beds were seen. South of the Naylin River, the Tertiary sedimentaries are succeeded by dark and greenish massive volcanic rocks, often slightly schistose and occasionally partly serpentinized, and further on by dark slates and greenish tuffs and conglomerates. At the 'Hudson's Bay' summit and for some miles to the north, the surface is covered by comparatively recent sheets of volcanic rocks. Three distinct flows are represented by an older compact basalt, a light-coloured acidic rock, probably a rhyolite, and a younger vesicular basalt. The wide plateaux of Level Mountain on the east and the Heart Mountains on the west of the trail are composed, in part at least, of similar rocks. East of the Hudson's Bay post, the valley of Hacket Creek is bordered above by basaltic cliffs on the north side, and by andesites and other porphyritic volcanics below. Pyrite, pyrrhotite and chalcopyrite are found in small quantities in these rocks. Farther to the east, tuffs, agglomerates and allied rocks partly replace the massive volcanics. At the 30-mile post, a band of yellowish-weathering dolomite crosses the trail. From the Tahltan River across the Telegraph summit to the Stikine, the rocks consist principally of fine-grained greenish tuffs, agglomerates and conglomerates, cut in places by augite-porphyrites and other massive volcanics of greater antiquity than those above referred to.

While delayed at Telegraph Creek, an examination was made of some claims on Nine-mile Creek, nine miles above Telegraph Creek, that have excited considerable interest. These claims have been staked out on a boss of eruptive rock, probably a diorite, about a third of a mile in width. The diorite varies from fine to coarse-grained in texture, is very basic and is filled in places with magnetic iron. It is bordered by greenish volcanic rocks, probably altered tuffs, on the west, and by a syenitic or granitic area on the east. Dykes of the last-named rocks penetrate the diorite in all directions, and occasionally carry small pockets of bornite and other copper minerals. A few small quartz veins also occur, but are unimportant. A number of specimens of the diorite, collected at different points along the face of the exposure, have been assayed, and are stated to have yielded from traces up to over a hundred dollars in gold to the ton. A further examination of a larger quantity of the gold-bearing rocks is now being made by Mr. J. C. Field, M.E., for the North American Exploration Company, and if the results of the previous assays are borne out, it will have an important bearing on the district, as the supply of material is almost unlimited. Assays of the specimens collected by myself will also be made in the Survey laboratory.

Work for the season was finished at Telegraph Creek. From that point we came down the Stikine in a small boat to Wrangel, and returned to Ottawa.

PRELIMINARY NOTE ON THE GOLD DEPOSITS AND GOLD MINING IN THE KLONDIKE REGION

by R. G. McConnell and J. B. Tyrrell

Messrs. R. G. McConnell and J. B. Tyrrell are jointly responsible for the following memoranda and observations bearing more directly on the question of the gold deposits and connected matters, the principal gold-bearing creeks of the Klondike having been visited by these gentlemen in company.

The productive part of the Klondike Gold District, as at present known, covers an area of 1000 square miles, and is situated between the

Klondike and Indian rivers, tributaries of the Yukon, and east of the latter river. The region is traversed by a multitude of streams, flowing for the most part in deep trough-like valleys, among the most important of which are Bonanza Creek (with its rich tributary Eldorado), Bear, Hunker, Too Much Gold, and All Gold creeks, flowing into the Klondike; and Dominion, Sulphur and Quartz creeks, branches of Indian river. The larger creeks are separated by long ridges gashed by the smaller streams and terminating upwards in even slopes or lines of rounded hills. The general aspect of the district, viewed from one of the higher elevations, is hilly, owing to the fact that the main ridges and creeks radiate out in a general way from a central point known as the Dome. The main ridges rise above the valleys from 1,200 to 1,500 feet, and in places are somewhat higher. The Dome, a name given to the prominent hill surmounting the ridge separating the tributaries of Indian river from the Klondike, and one of the highest points in the region, has an elevation above the Yukon river of about 3,000 feet. East of the hilly region centring in the Dome, at a distance of eight to ten miles, is a wide plain drained by a branch of the Klondike, beyond which, and closing in the horizon, runs a high range of rugged peaks. The district, with the exception of the higher peaks and ridges and occasional flats along the streams, is covered with a fairly heavy forest growth, consisting principally of the white and black spruce with some birch and poplar.

Productive Area

The approximate area of 1000 square miles, given above as the probable extent of the known gold field, refers to the district traversed by the gold-bearing creeks, and not to the actual area of pay gravels. The latter are confined to the bottoms of a few of the valleys and the lower slopes of the adjoining ridges and occupy a much smaller area. The rich creeks, so far, are only four in number, viz.: Eldorado, Bonanza, Hunker and Dominion, and by far the greater proportion of the remarkable yield of the last two years has come from Eldorado and Bonanza. The proved portions of the four producing creeks have an aggregate length of about thirty miles. A number of tributaries of the producing creeks, and other streams such as Bear, Sulphur, Too Much Gold, All Gold and many more, have yielded small amounts, and it is confidently expected that the prospecting work now in progress will result in large additions to the producing area.

Mode of Occurrence of Gold

The gold occurs in the gravels flooring the bottom of the valleys, in stream-terraces lining the lower slopes of the valleys and in a remarkable moraine or glacial deposit that occurs along the southern slopes of Eldorado and Bonanza creeks for some miles, and was also found north of the latter creek for some distance above its junction with Eldorado.

The stream-gravels are very uniform in character throughout the district. They consist mainly of flattened sub-angular schist pebbles, ranging in size from small scales up to rounded or elliptical plates a foot or more in width, coarse round pebbles and boulders of quartz and occasional layers of clayey vegetable mould. The gravels rest on a slightly irregular floor of decomposed mica-schist and quartz-schist. They have a thickness of from two to eight feet and a width along the most productive portions of Eldorado and Bonanza creeks of from one hundred to four hundred feet. They extend across the valley-bottoms and increase in width with the gradual enlargement of the latter towards their mouths.

The gravels are overlain in all cases by a layer of black argillaceous vegetable matter of three feet or more in thickness.

The gravels are everywhere more or less auriferous, but, as in other placer camps, the concentration is very irregular, and the gold increases in quantity towards the bottom of the section, the greater part of the pay being found usually within eighteen inches or two feet of bed-rock. A considerable portion of the gold is also found in the soft decomposed and shattered country-rock on which the gravels rest, into which it has sunk often to a depth of two feet. The pay-streaks range in width from a few feet to a hundred feet or more. They are interrupted along the length of the creek by comparatively barren stretches, and in places more than one pay-streak is found in prospecting across the rocky bottom. The minimum richness of the gravels considered as 'pay' by the miners, on an average claim, is given at about \$5 to the cubic yard, but varied according to different informants from \$4 to \$7.

The bench-gravels are of less importance than the stream-gravels and so far are only worked to an inconsiderable extent along Bonanza and the lower part of Eldorado Creek. The benches only occur at intervals along the sides of the valley and as a rule are rock-cut and not built up by stream deposits. They are found at varying heights up to an elevation of seventy-five feet or more above the bottom of the valley.

In ascending Bonanza Creek the first bench claims were found opposite No. 60 below Discovery, on the south side of the valley. The bench has an elevation of seventy-five feet above the bottom of the valley and consists of sixty-seven feet of schists of various kinds terminating upwards in a flat surface and overlain by eight feet of gravels. The bench is wide, as it occurs on a projecting point, but does not extend far along the valley. The gravels are mixed with sand and consist of flat and sub-angular pebbles of schist often a foot or more across and rounder quartz pebbles. The gold is fine, but nuggets up to a value of \$1.35 are reported to have been found. The average yield of the gravels is stated to vary from 5 cents to 20 cents to the pan. Several bench claims similar in character to the one just described, but at lower elevations, were being worked further up on Bonanza Creek and on the lower part of Eldorado. On Hunker Creek, only one claim of the kind was being worked at the time of our visit, and on Dominion Creek none were in operation.

Hill claims, situated on the moraines mentioned above as occurring along Bonanza and Eldorado creeks, are being extensively worked and in some cases have proved extremely rich. The moraines are situated at an elevation of from 150 to 200 feet above the bottom of the valley, have a width of from 200 to 300 feet or more and a thickness in the centre of 50 feet or more. The most productive claims occur along the lowest edge of the deposit and are worked by open cuts. The gravels are washed in rockers as the water supply is insufficient for sluicing. The morainic material is auriferous throughout, but the greater part of the gold is found at or near the sloping surface of the bed-rock at the bottom of a bed of coarse gravel, which consists of rock-flour, sand, pebbles and boulders. The gold, which is often in large nuggets, usually includes much quartz, and is rough and unrounded.

Conditions of Working

As stated above, the stream deposits consist of beds of gravel varying from two or three to fifteen or twenty feet in thickness, overlain by a mass of vegetable material, locally known as 'muck', from four to eight feet or more in thickness. This muck is chiefly sphagnum bog, or peat, which has suffered little decay since it grew where it now rests. Both the peat and the gravel are permanently frozen, and as the peat is an excellent non-conductor of heat, the gravel continues frozen as long as it remains covered by even a thin coating of peat.

After the prospector has found indications favourable enough to induce him to stake off a claim, he can readily prospect it thoroughly in winter by building a fire on the surface, removing the thawed earth, building another fire on the same spot, again removing the ground that has been thawed, and so on down to bed-rock. The sides of the shaft so sunk remain firm and solid. In summer, however, it is difficult to sink a shaft in this way, as the sides are likely to cave in, so that prospectors then build a fire upon the open ground, heat stones very hot and throw them down the shaft, covering them with brush or anything else that will prevent the heat from ascending. These stones will, in a night, thaw the ground to a depth of from 6 to 9 inches. This thawed ground is taken out, and the process is repeated until bed-rock is reached. If pay gravel is struck it may be thawed and removed from around the bottom of the shaft until a large circular 'room' is formed in the gravel. The gravel raised is afterwards sluiced, and the gold extracted from it.

The most economic method of working creek claims is by open cuts. The barren muck overlying the gravel is got rid of early in the season by the simple device of damming up the stream and leading it by several channels across the claim. The frozen muck dissolves readily and is usually completely removed by the stream in the course of a few weeks. The underlying auriferous gravels, as they become gradually thawed out and loosened by the sun and the various atmospheric agencies are shovelled into sluice boxes and washed in the ordinary way. When the surface is kept clean thawing proceeds at the rate of from two to four inches a day and bed-rock is reached before the season closes.

On the dry benches in the northern part of the Yukon district, the ground was found not to be frozen in summer, and probably some of the drier and more open tracts in the Klondike district are not permanently frozen.

On the hill-sides, as well as in the bottoms of many of the valleys, there are large quantities of earth and gravel that are too poor to admit of being worked by the ordinary method of sluicing or rocking now in use, and to yield good results will require to be worked on a larger scale and by more economical methods.

The clays and gravels when exposed in summer in the creek beds and on the hill-sides, thaw very quickly leaving them loose and friable and in a favourable condition to be acted on by water. The available water in the Klondike creeks is however too limited for work on a large scale and the problem of obtaining a supply from other sources has not yet been solved. The grade of the Klondike River is fairly steep and it is possible that water might be flumed from it. This could only be done at a great cost, as the river would have to be tapped far up. The gravels are, however, exceptionally rich even in many portions of the creeks too lean to pay by present methods of working and would justify a heavy expenditure in their exploitation.

To install extensive plants either for hydraulicking or sluicing blocks of ground, large sums of money will be needed, and in order to encourage the influx of this capital into the country it will be necessary to offer every facility to investors. It should thus be not only possible but reasonably easy for them to consolidate groups of claims or to obtain blocks of land of sufficient size to make it probable that they would receive a fair return for their investment, especially in the case of lands not sufficiently rich to be profitably worked by hand.

Gradients

As the valleys are wide and U-shaped, the grades of their beds are not at all steep. The Forks of Bonanza and Eldorado creeks, about 12 miles from Dawson, is about 500 feet above the Yukon River at that place, giving lower Bonanza and the Klondike River combined an average grade for that distance of something over 40 feet to the mile. Bonanza Creek, from the mouth of Cormacks Creek to the Forks, has a drop of about 500 feet, giving a fall of a little less than 100 feet to the mile. The grade of Eldorado Creek is somewhat steeper, the descent from the mouth of Chief Gulch to the Forks, a distance of about four and a-half miles, being about 700 feet, or an average of about 150 feet to the mile.

Above these points, the grades become rapidly steeper and the streams are narrower, so that it might be possible to build dams across them and construct large reservoirs, from which a supply of water could be obtained to serve for washing the lower parts of the hill-sides further down.

Source or Sources of the Placer Gold

As has been pointed out by Mr. J. E. Spurr of the United States Geological Survey, in the case of the country of Forty-mile Creek and further north and west, the gold in the Klondike has certainly been derived from the rocks of the immediate vicinity, for there is no evidence of the transportation of material of any kind from a distance. The rock underlying the district is a quartzose, micaceous and sericitic schist, in which many lenticular stringers of quartz lie parallel to the bedding, and through which some large veins of quartz run in other directions. In a few places dikes of dark-green basic rocks as well, as lighter coloured porphyries cut through the schist, but it is not probable that these intrusives have any influence on its gold-bearing character.

On Bonanza and Eldorado creeks, one band of the schists is highly graphitic, while near the mouth of Hunker Creek there is a heavy band of granular limestone.

Granite was reported to occur a short distance up the Klondike but the outcrop was not seen.

The schists are sedimentary or crushed massive volcanic rocks of early Palæozoic, probably Cambrian age, which have been highly altered by dynamic agencies, the quartz veins having doubtless been formed in them while they were undergoing this metamorphism.

The rocks of this group have been traced northward and westward by the geologists of the United States Geological Survey into the Forty-mile and Sixty-mile district. Southward they have not as yet been exactly correlated with any of the rocks known to occur in Canada, though they may be of the same age as the schists and limestones on Nisling River and along other portions of the Dalton Trail.

That the gold in its original habitat has been associated with quartz there can be no doubt, for many masses of gold-bearing quartz have been found, and many of the nuggets of gold contain particles of quartz. Whether the gold is chiefly derived from the heavy veins or from the narrow stringers has not yet been determined, but it is probable that in places both are auriferous. We found particles of gold in a thick quartz vein north of Eldorado Creek, but as the abundance or scarcity of the placer gold did not appear to depend on the size or number of these heavy veins, it is probable that the precious metal has been chiefly derived from the narrow stringers or leaves of quartz interbedded in the schist.

The great ice-sheet of the Glacial period which covered much of British Columbia, did not reach as far north as the Klondike district, so that ever since the land was elevated above the sea, perhaps in the Miocene or Pliocene epoch, it has been cut down continuously by atmospheric and stream agencies forming deep valleys, with intervening rounded hills still covered by a varying thickness of decomposed rock. There is no doubt that much of this decomposed rock, in the Klondike area, contains a small amount of gold, and by constant washing for ages, much of this has become concentrated in the beds of the streams. On Bonanza and Eldorado creeks, and doubtless also on a number of the other creeks that rise in the high land near the Dome, the work of concentration has been greatly expedited by small local glaciers*, which, at a period not very remote, have originated at the heads of these creeks, and have filled the bottoms of their valleys through parts at least of their lengths. Thus the Eldorado glacier would appear to have had a greatest thickness of about 200 feet at French Gulch, and to have joined the Bonanza glacier at the Forks, below which both continued on some distance together. The gravel that fills the bottom of the valley from side to side is a typical glacier-wash, having been deposited by the stream which flowed from the face of the glacier. The lower benches on Bonanza Creek were also deposited in a similar way, but the higher so-called benches have been formed either as lateral moraines along the sides of the glacier or by streams which flowed between the side of the glacier and the bounding slope of the valley.

The great richness of the Klondike placer ground depends, therefore, first on the presence of a highly gold-bearing rock, and, secondly, on the occurrence of a set of conditions peculiarly favourable to the concentration of the precious metal.

Communication

Last summer it was necessary to transport provisions and supplies from Dawson to the various creeks on the backs of men or horses by trails through swamps and along stony hill-sides which were about as bad as they could be. Good wagon roads could, however, readily be built from Dawson up the various creeks tributary to the Klondike River and thence possibly across to Dominion Creek, and thus to the tributaries of Indian River. From the Yukon River a good wagon road could in all probability be easily built from the mouth of Indian River up to the very sources of most of the

* Later, the idea that these glaciers had existed was abandoned by McConnell.

tributaries. In fact, good and direct roads could easily be built through that whole country, for the hill-slopes are everywhere light and the bogs in the bottoms of the valleys are nowhere very deep, while lakes are conspicuously absent.

Fuel

The country is more or less thickly wooded with white and black spruce, white and black poplar, and canoe birch. The largest timber is in the bottom of the valleys, some of the white spruce on the flat near the mouth of Bonanza Creek forming a forest of fine tall trees fourteen to eighteen inches in diameter. Excellent timber also extends in places up the sides of the hills to a height of several hundred feet above the level of the Yukon at Dawson, the spruce being mixed with large white poplars. At higher elevations the forest becomes thinner and the trees smaller, until at an elevation of about 2500 feet above Dawson, the timber limit is reached, the higher crests and summits in the vicinity of the Dome being devoid of timber and clothed only with small hardy alpine and arctic plants. If used with reasonable care, there is an abundance of wood in the country to supply the wants of the people for a number of years both in fuel and building timber. The greatest care, however, should be exercised to prevent forest fires which might in a very short time deprive those who are attempting to develop the resources of that country of one of their most valuable assets.

Lignitic coal or lignite is reported to have been found on Klondike River about forty miles above Dawson, but no definite information has been obtained about it. It is possible that there may be coal seams here which will furnish a valuable local supply of fuel.

Cost of Living

During the past year the expenses of working mines have been abnormally high on account of the scarcity of labour, and the very high prices of machinery and provisions, these prices being due not so much to the inherent difficulty and expense of transporting provisions into the country as to the fact that the means of transport into the country were quite inadequate to supply the people who swarmed into the Yukon district. This summer, however, wages had fallen to about a half of what was paid last winter, and it was found quite possible to purchase provisions at retail prices at the stores, for the maintenance of a party, at less than a dollar a day per man.

1899

Introductory Note

Dr. G. M. Dawson, Director, introduces the section of his Summary Report on "Yukon District" for 1899, page 16A, with the following paragraph.

"Mr. R. G. McConnell, during the summer of 1899, continued his examination of the richly auriferous territory in the Klondike division of the Yukon district. He was assisted by Mr. J. F. E. Johnston, who undertook the topographical work necessary for the mapping of the rock formations and gold-bearing gravels. Because of the amount of inquiry directed to this region, Mr. McConnell has been requested to furnish a somewhat full preliminary report upon it, which follows."

The report that followed had already been printed in advance as a separate pamphlet (No. 687, 44 pages) entitled 'Preliminary Report on the Klondike Gold Fields, Yukon District, Canada'. Though out of print, the report is not included in this volume, as the contained information is revised and enlarged upon in McConnell's later and more complete report on the Klondike gold fields following his investigation in the same area in 1903. This later report is reproduced here (*see* 1903) in full.

1900

Introductory Note

In the summer of 1900, R. G. McConnell returned to the Klondike district and made an examination of Tintina Valley from Klondike River to the mouth of Clear Creek on Stewart River. He then ascended Stewart River to Frazer Falls, and explored the geology from there down the Stewart to its mouth and thence down the Yukon to a point about 11 miles below Cliff Creek. He visited the prospects in the Tertiary lignite areas nearest to Dawson, and while on his way through Whitehorse made his first examination of the nearby copper prospects in what was later to be known as the Whitehorse Copper Belt. His report on the summer's field work was published in the Summary Report for 1900, and is referred to as a preliminary report by Dawson in his introductory paragraph, given below. Later, following more field work, McConnell wrote complete reports on the Klondike mining district and the Whitehorse Copper Belt, but the report of 1900 remains his only account of the geology of Stewart and Yukon River Valleys and of the lignite occurrences near Dawson.

Mr. R. G. McConnell was occupied during the winter of 1900 exclusively in work connected with the elaboration of his observations in the Klondike region. During the past summer he was again occupied in the exploration of this and other parts of the Yukon district, with interesting results, of which a pretty full preliminary account is given by him in the following report.

EXPLORATION OF TINTINA VALLEY FROM THE KLONDIKE TO STEWART RIVER

by R. G. McConnell

I left Ottawa on May 27th, but was delayed at Skagway and White Horse for some days by the lowness of the water at the head of Lake Laberge, and did not reach Dawson until June 20th. I was accompanied by Mr. J. F. E. Johnson, who acted as topographical assistant.

A few days were spent in the vicinity of Dawson, completing the geological mapping of the surrounding district, and in making a hasty examination of the principal producing creeks. On July 13th, I started with one man and a pack-horse, for the mouth of Clear creek, a tributary of the Stewart, examining on the way the great gravel plain east of the Klondike hills, commonly described as the old bed of the Stewart. The mouth of Clear creek was reached on July 21st, and on the 25th Mr. Johnson, who had ascended the Yukon to the mouth of the Stewart in a steamer, and the latter river in a canoe, making a track-survey on the way, joined me. Mr. Johnson returned overland while I continued up the Stewart to the Frazer falls, which were reached on August 3rd. On the return journey, a geological examination of the Stewart valley was made from the Frazer falls down to its mouth, and a few days were also spent on the Yukon between the mouth of the Stewart river and Dawson.

After returning to Dawson, trips were made to the Indian river for the purpose of examining the reported gold-bearing conglomerates opposite the mouth of Quartz creek, and to the Coal creek and Cliff creek coal mines. The Yukon valley was also examined from Dawson down to the mouth of Cliff creek. On the way out a stop was made at White Horse, and a preliminary examination was made of the important copper belt recently discovered west of that point.

The Klondike gold-bearing gravels were described in last year's Summary Report, and as no important discoveries of new creeks were made during the season, it will be unnecessary to dwell on them here. The production of the old creeks and benches has been large and is expected to exceed the great yield ($16,000,000) of the preceding year, but as the full returns have not been received it is impossible to give the exact figures. The increased use of machinery, more especially steam hoists and thawing machines, has largely contributed to the result. No attempt has yet been made to work any of the concessions on a large scale, and very little preparatory work is being done on them.

The gravel basin east of the Klondike hills, extending north-west of the Stewart to the Klondike river, was prospected in a couple of places during the season, but so far as could be learned with indifferent results. This great body of gravel, measuring from ten to fifteen miles in width and in places exceeding 600 feet in thickness, carries fine colours nearly everywhere, and there is a possibility that in places the gold may be found concentrated in paying quantities. The extent and thickness of the gravel deposit will however necessitate expensive prospecting work. The gravel consists principally of quartzites, hard schists and various kinds of eruptive rocks, among which granite is conspicuous, and has been derived principally from the east and south-east. The sources of the contained gold must also be looked for in the same direction.

Stewart River, from Frazer Falls to its Mouth

The Stewart is one of the main tributaries of the Yukon. It rises in the unexplored Pacific-Arctic watershed ranges lying between the heads of the Peel and Pelly rivers, and flows in a general westerly direction towards the Yukon valley. From Frazer falls to its mouth, a distance of nearly 200 miles, it is a large stream, seldom less than 150 yards in width and often more than double this breadth. It is navigable throughout the season by ordinary shallow-draught river steamers all the way to the Frazer falls. From the Mayo to its mouth, the current flows from three to five miles an hour with occasional accelerations on the bars. Above Mayo river, the current decreases to a rate of from two to three miles an hour and bars are almost entirely absent. At the Frazer falls, the Stewart flows for a third of a mile with great velocity through a narrow cañon bounded by vertical walls of hard quartzose schist. The word falls is a misnomer, as the grade in the cañon is fairly uniform and the total descent was estimated to be only thirty feet. Above the falls the river is interrupted by occasional short riffles for several miles, but, farther up, its course is reported to be clear to the main forks, a distance of about sixty miles, and up the north branch for a considerable stretch beyond. The east branch is reported to be a rapid stream constantly interrupted by rapids and cañons. The principal tributaries of the Stewart below Frazer falls are the McQuesten and Mayo rivers, both fair sized streams, and Clear creek from the north, and Crooked river, Lake creek and Scroggie creek from the south.

The country bordering the lower part of the Stewart river is nearly everywhere of a mountainous character, and may be described as a high plateau deeply dissected by a multitude of wide and often interlocking valleys. The hills project above the valleys in isolated masses, in irregular shaped groups, and in well defined ranges. The outlines are generally rounded and the elevations range from about 2,500 feet to 4,000 feet above the main valleys. The lower slopes are clothed with a forest of spruce, poplar, birch, willow and alder. Above a height of about 2,500 feet the surfaces are usually bare. The bottom-lands of the Stewart often exceed two miles in width and are seldom less than a mile, and those of many of the tributaries, notably Crooked river and Lake creek are even wider. Below the mouth of Clear creek, the Stewart has cut a comparatively narrow rock-walled channel through the bottom of the older valley. The deepening of the valley is evidently due to the same elevatory movement that affected the Klondike region and gives evidence of the wide extent of that uplift.

The Stewart River valley affords a good geological section, but as the rock-specimens have not yet been examined, this can only be briefly described here. At the Frazer falls the river cuts through hard, quartzose, greenish schists, apparently partly crushed eruptives, alternating with bands of softer green chloritic schists and dark argillites. These schists, including in places beds and bands of quartzites, are exposed along the valley all the way down to a point five miles above Moose creek. At Canyon creek a hard slightly squeezed basic eruptive is included in the series, or overlies it. The dips as a rule are not high, seldom exceeding 45°, and the general strike is to the south-east.

Above Moose creek, the schists are cut by granite, and along the valley down almost to Lake creek, granitoid rocks of various kinds occur. The principal variety is a coarse-grained grayish granular rock consisting principally of orthoclase, a plagioclase felspar (probably oligoclase) quartz and biotite. A reddish variety occurring above the mouth of the McQuesten contains a good deal of hornblende in addition to the biotite. At many points the granite becomes strongly porphyritic. The gray granite alternates with, and in many places appears to cut a dark eruptive of a dioritic character, but it is probable that the latter simply represents a more basic phase of the same magma. Both the dark-coloured and gray rocks are cut by a system of dark diorite dykes. The granites are massive in character and do not exhibit evidence of much squeezing.

At the mouth of Lake creek, the granitoid rocks are replaced in the valley by a series of old looking schists, largely of the character of granite-gneisses. They vary in texture from fine- to coarse-grained and often pass into augen-gneisses. They are associated with coarse mica-schists, green chloritic schists and dark hornblende-schists. The beds dip at high angles and usually exhibit the short sharp foldings characteristic of the old Archæan gneisses. They have a width in the Stewart valley of about nineteen miles, and are probably a continuation to the south of the band of augen-gneisses described in last year's report as occurring on the upper part of Australia creek, but they have not been traced across the interval. Similar granite-gneisses have been observed by Mr. Spurr* in the Forty-mile region, and by Mr. Brooks** on White river, and are described by them as being probably the oldest rocks in the district. The evidence on this point is not clear in the Stewart River valley, and there is a possibility that they represent a great intrusive mass older than the massive granites described above, but

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* U.S. Geological Survey, Eighteenth Annual Report, Part III, p. 134.
** U.S. Geological Survey, Twentieth Annual Report, Part VII, p. 460.

younger than the highly altered rocks exposed along the lower part of the Stewart valley.

The granite-gneisses are succeeded by a group of rocks which, so far as known, include the oldest sedimentaries of the district. The characteristic variety is a gray fine-grained gneissic-looking schist consisting largely of angular quartz grains with some felspar. Biotite is nearly always present, but in variable quantities. In many sections the schists have a banded appearance, due to the alternation in thin beds of a light-gray quartz-schist, carrying a few scattered biotite scales arranged parallel to the bedding, with a dark-gray more micaceous variety of the same rock. These schists are everywhere highly altered and in many instances are so completely re-crystallized that their origin is doubtful. A preliminary examination of a few thin sections, shows that both clastic and igneous rocks are present, the former probably preponderating. The metamorphism has, however, been so complete over large areas that the two kinds are often indistinguishable in the field. In addition to the gray schists, the series includes bands of dark diorite-schists, green chloritic and actinolitic schists, bright lustrous mica-schists and numerous beds of white crystalline limestone. The strata just described occupy the Stewart valley down to its junction with the Yukon and are also found west of the Yukon on the lower part of White river where schists of an almost identical character have been described by Mr. Brooks* under the name of the Nasina series. This name will be employed by the writer in referring to these rocks. In the Forty-mile district the Birch Creek series and the Forty-mile series of Mr. Spurr probably represent the same group, but no such line of division as that assumed by him could be drawn in the Stewart River section. The schists of the Nasina series apparently overlie the granite-gneisses which border them on the east. The dips are usually moderate, seldom exceeding 40°, and there is a marked absence of the sharp foldings so prevalent in the granite-gneiss area. The apparent superior position of the Nasina series and the small amount of deformation its rocks have suffered as compared with the granite-gneisses, leads to the inference that they are younger than the latter, but is not conclusive proof. The contact of the two formations was nowhere seen, and bosses of sheared granite, similar to and possibly of the same age as the granite-gneiss, cut the Nasina series at several points.

The Nasina schists are cut in all directions by numerous dykes and stocks belonging to several distinct periods of eruption. The oldest are the sheared granites referred to above. A younger looking gray massive granite also occurs in dykes and considerable areas all along the lower part of the valley. A group of acid dykes, probably mostly rhyolites, crosses the valley a few miles below the eastern boundary of the Nasina schists. They have been silicified and mineralized to some extent and form conspicuous yellow and red bluffs along the north bank of the river for some distance. Dark andesitic dykes were also noticed in a number of the exposures.

The glacial features of the Stewart valley are interesting, as the upper part is in a glaciated and the lower in an unglaciated region. At Frazer falls the rocks are strongly glaciated in a direction nearly parallel to that of the valley and groovings also occur at several points lower down. Typical boulder-clay occurs in banks at intervals down to a point about ten miles below Mayo river. Below Mayo river a wide ridge 200 feet in height crosses

* Ibid., p. 465.

the valley. The ridge is several miles in width and is built of silt, sand and gravel alternating with and often capped by bands of boulder-clay. A narrow depression bordered by steep scarped banks has been cut through it by the river. This ridge must have formed at one period a great dam across the valley, as above it the flats bordering the river are low and the drift deposits occur only in narrow terraces along the sides of the valley. It still acts as a dam to some extent, as the Stewart is sluggish above the Mayo river almost to Frazer falls. Below the ridge, the boulder-clay and accompanying glaciated boulders soon disappear, but high terraces of silt, sand and gravel continue along both sides of the valley down to the McQuesten and are occasionally cut by the river at the elbows of the bends. A high cut-bank two miles and a half below the mouth of Moose creek includes a thick bed of hard sandy clay resembling boulder-clay but containing rolled, instead of glaciated pebbles. In the lower part of the valley the gravel banks consist entirely of ordinary stream wash.

The Stewart River bars were found to be auriferous as early as 1885, and in that and the two succeeding years it is estimated the yield amounted to about $100,000. Prospecting has been carried on to some extent ever since, but the production has been small. Bars have been worked from the Mayo forks down almost to the mouth of the river. In most of the bars which were worked, the auriferous deposit was less than a foot in thickness, and was confined to a small area near the head of each bar. The extreme shallowness of the gold-bearing gravels accounts for the rapid exhaustion of the Stewart River diggings. During the past season no work of any kind was being done on the main stream below the Frazer falls. On the tributaries, some work was done on Scroggie creek, on some creeks near the head of the McQuesten, where some gold was taken out, and, late in the season, a strike was reported on Clear creek. A number of prospectors are wintering above Frazer falls and a good deal of prospecting will be carried out, on the upper waters of the river, during the coming season.

The gold on the Stewart River bars is fine, and there is every reason to believe that it has been concentrated from the high gravel and sand banks described above as occurring along the valley from the Mayo down to the McQuesten. The gravels nearly everywhere contain scattered colours, and they are constantly being undermined and carried away by the river. During the past season a prospecting party under Mr. Morley Ogilvie, examined the lower part of the river for dredging purposes and the results are reported to be very favourable. The gold in the bed of the river proved to be coarser than on the bars and was found in encouraging quantities. The conditions on the river are favourable for dredging as the current, except in a few places, is not swift and the gravel is comparatively fine with few large boulders.

The Yukon River Section, from Stewart River to Eleven Miles below Cliff Creek

The rocks outcropping along the Yukon river were examined with some care from the mouth of the Stewart down to Cliff creek, eleven miles below Forty-mile river. It was intended to continue the examination to the boundary but time did not permit. Below the Stewart the quartz-schists, crystalline limestones, hornblende-schists and other schists of the Nasina series, undulate in broad folds along the valley down to a point about four miles above Indian river, when they are overlain by the dark siliceous slates described in the Summary Report of 1899 as the Indian River series. The Indian River beds occupy the same position as the Nisconlith slates of southern British Columbia. They rest, apparently, conformably on the schists of the Nasina series and differ from them principally in being less completely altered and in their darker coloration. They include occasional bands of limestone and green schist.

Two miles below Ensley creek, the Indian River slates are cut off and replaced by the light coloured sericitic schists or squeezed quartz-porphyries of the Klondike series. The latter, holding in places irregular-shaped inclusions of the older slates outcrop, in continuous sections along the valley down almost to the Klondike river. They extend in a wide band south-easterly to Australia creek, and constitute, as stated in last year's report, the gold-bearing rocks of the Klondike district. The Klondike schists are succeeded by a set of green, mostly diabasic rocks which the writer, for purposes of local description, has called the Moosehide group, and which are apparently older than the quartz-porphyries of the Klondike series. They occur both in a massive and schistose condition and are often altered into serpentine. Below Moosehide mountain, the section down nearly to Forty-mile river consists principally of thick bands of green schists and dark lead-coloured argillites alternating above with gray limestones. A few miles above Forty-mile river, the upper part of the Nasina schists and overlying Indian River slates are exposed for some distance in the axis of a broad anticline which crosses the valley in a diagonal direction. Below Forty-mile river the upper and less altered green and dark schists resume and continue down to Cliff creek, where the examination ended.

In addition to the bedded or shistose rocks described above, igneous rocks, in great variety, are displayed along the Yukon Valley section. Sheared and massive granites occur in considerable areas at many points and granitic and pegmatite veins are seldom absent. Effusive rocks are represented by an area of andesite below Indian river and a basaltic area a few miles above Forty-mile river. Dykes of andesite, basalt, quartz-porphyry and allied rocks are also common, especially between Indian river and Forty-mile river.

Lignite Areas

Lignite-bearing beds outcrop on the Klondike river six miles below Flat creek and extend in a north north-westerly direction in a long narrow basin or series of basins to Cliff creek a distance of sixty miles and probably for some miles beyond. They follow in a general way the course of the Yukon valley, from which they are separated by a narrow strip of the older rocks. Wide valleys are cut across them by all the streams entering this portion of the Yukon from the north-east, but owing to their soft character exposures are infrequent. In their normal condition the beds consist of soft slightly coherent sandstones and conglomerates, alternating with light- and dark-coloured clays and shales. In places where the beds have been strongly folded, the clays and sands are altered into sandstones and shales. The age of the lignite beds is uncertain as no fossils were found in them, but they probably belong to the Tertiary.

A lignite horizon, with one or more seams, occurs in this formation at a number of widely separated points, and apparently accompanies it throughout its whole extent. Seams of lignite outcrop on Rock creek and its tributary Coal creek at the southern end of the area, on Cliff creek at the northern end, and on Twelve-mile creek, Fifteen-mile creek and Coal creek at intermediate points, and it is reported from a number of other localities. The total area underlain by lignite is estimated to considerably exceed 200 square miles.

The Alaska Exploration Co. has taken up a block of coal lands on Coal creek, and has commenced mining operations at a point a little over seven miles from the Klondike river following Coal Creek and Rock Creek valleys, and about twenty miles from Dawson. Lignite outcrops at this point in the face of a low rounded hill, part of which has been cut away by the stream. The hill seems to be due to a recent uplift, as the dips of the strata approximately follow its slopes. The section on the exposed face of the hill is of soft, slightly coherent micaceous sandstones and brownish clays, holding a broken bed of lignite. The workings of the mine consist of an incline about 400 feet in length, descending in a south-easterly direction at an average angle of about 25° for the first 200 feet, beyond which the angle gradually decreases to about 4°. A short drift has been driven in a north-easterly direction, following the seam, at a point 225 feet from the mouth of the incline. The seam dips to the north-east in the drift at angles of from 3° to 10°.

The strata in the upper part of the incline have been disturbed and faulted to some extent, and the lignite beds occur in a broken condition. In the lower part of the incline and in the drifts, the beds are continuous although the dips are still irregular. The disturbance appears to have been quite local and will probably not affect the beds for any considerable distance. It is impossible, however, to speak definitely on this point, as no surface sections are available for study. Two seams of lignite are present in the lower part of the incline and in the drifts. The upper seam has three feet of hard lignite, and the lower from two to three feet. The two seams are separated by a clay parting about a foot thick and are roofed and floored with clay. The lignite is hard and compact and shows no traces of the woody fibre so common in lignites. It is probable, as suggested by Dr. Hoffmann, that it originated largely from mosses and other low forms of vegetable growth. It is of good quality, burns freely and can be used both for heating and steam purposes.

The following analyses of the two seams have been furnished by Dr. Hoffmann:

Lignite from upper seam Coal Creek mine:

Hygroscopic water	18·31
Volatile combustible matter	34·96
Fixed carbon	40·88
Ash	5·85
	100·00
Coke per centage (non-coherent)	46·73

Lignite from lower seam Coal Creek mine:

Hygroscopic water	19·37
Volatile combustible matter	33·85
Fixed carbon	37·45
Ash	9·33
	100 00
Coke per centage (non-coherent)	46·78

In working Tertiary lignites it is well to bear in mind that the seams as a rule are not so regular or so persistent as in the older formations and the use of the diamond drill for exploratory purposes is strongly recommended before commencing operations on a large scale. In the case of the Coal Creek mine the precaution is rendered all the more necessary by the almost complete absence of surface sections in the neighbourhood.

The North American Trading and Transportation Co. has opened up a group of lignite seams at Cliff creek, a small stream which enters the Yukon from the right, fifty-five miles below Dawson. The workings are situated about a mile and three-quarters from the mouth of the creek and consist of two long tunnels with a number of drifts and 'upraises'. The lower tunnel is on the right side of the creek and the upper a short distance farther up the creek on the left side. The distance along the zone from the mouth of the first tunnel to the end of the second is 2,800 feet, and the seams appear to be continuous for this distance and probably extend much farther.

The tunnel at the upper workings has been driven mostly along the lignite zone, for a distance of 800 feet. At one point, 225 feet from the mouth of the tunnel, the coal seams are bent to one side and probably faulted. The lignite zone, consisting of alternating beds of lignite, clay and carbonaceous shale, measures over forty feet in thickness in places. The included lignite seams vary in thickness from a few inches up to five feet. A section 300 feet from the mouth of the tunnel showed over eleven feet of coal, in seams separated by clay partings and beds, as follows:

	Feet	Inches
Lignite	1	6
Thin parting—	—	—
Lignite	0	5
Carbonaceous shale	0	3
Lignite	0	6
Shale	0	1
Lignite	2	0
Clay	1	3
Lignite	1	3
Clay	3	0
Lignite	1	0
	15	10

The beds have a nearly east-and-west strike and dip in a southerly direction at angles of from 50° to 75°.

A section in the lower workings showed:

	Feet	Inches
Shales		
Lignite, one thin parting	9	0
Shales	2	0
White clay	2	9
Alternating clays and shales	3	0
Grayish clay	13	0
Carbonaceous clay	3	3
Lignite, one parting	3	0
Carbonaceous shales and clays	6	0
Soft sandstone with layers of grit	10	0
	51	9

The dip of the beds in the lower workings is much less than in the upper, and in places they are almost horizontal.

The Cliff Creek lignite is very similar in appearance to the Rock Creek variety. It is dark in colour, compact, and probably somewhat harder than the latter, as the inclosing rocks are more indurated. Dr. Hoffmann describes it as a lignite of superior quality closely approaching to a lignitic coal. The following analyses were made in the laboratory of the Survey:

Lignite from upper and lower workings, Cliff creek.

An analysis by fast coking gave:	Upper Working	Lower Working
Hygroscopic water	8·57	10·58
Volatile combustible matter	42·04	40·10
Fixed carbon	45·77	46·74
Ash	3·62	2·58
	100·00	100·00
Coke per cent	49·39	49·32

Coke of lignite from upper working,—feebly coherent, tender.
" " lower working,—non-coherent.

A considerable quantity of coal from the Cliff creek mines was shipped to Dawson during the past season for heating purposes, and it is also used by a number of the river steamers with satisfactory results. The coal is sold on the wharf at the mouth of Cliff creek for $10 a ton, and in Dawson for $20 a ton, and upwards. A narrow gauge railway has been built from the workings to the river, and the mine is now in a condition to supply a large demand.

The coal outcrops on Coal creek and Fifteen-mile Creek were not examined. The Tertiary area on Indian river, opposite the mouth of Quartz creek is also reported to contain coal. The beds in this area are cut and hardened by igneous intrusions, and if they carry coal, it is likely to be harder and of a better quality than in the less disturbed districts.

Lignite seams occur on the Lewes above Rink rapid, and during the last season a possibly important discovery of anthracite coal was made west of Dugdale station on the White Pass railway and only a few miles from the White Horse copper district. The specimens sent in for examination are crushed and coarsely foliated. The following is the result of an analysis made in the laboratory of the Survey:

Hygroscopic water	2·31
Volatile combustible matter	5·59
Fixed carbon	67·20
Ash	24·90
	100·00
Coke per centage (non-coherent)	92·10

The percentage of ash in the specimen assayed is high, but it is possible that a purer variety may be discovered in the course of the exploration now in progress.

White Horse Copper Deposits

The White Horse mineral area is situated west of the White Horse rapids on the Lewes river. The principal discoveries have been made along a belt about ten miles in length, running in a north-westerly and south-easterly direction or nearly parallel to the course of the Lewes and from two to four miles distant from it. The Lewes is bordered at this point, on the left, by a strip of rough plateau country closed in on the south-west by a range of mountains. The portion of the plateau adjoining the mountains may be said to constitute the mineralized district so far as known at present.

The geology of the district is simple, in its main features at least. West of the river and occupying the greater portion of the plateau is a lenticular area of gray often hornblendic granite. The eastern edge of the granite is mostly covered by drift, but on the west it cuts and often holds inclusions of gray crystalline limestone of unknown age. The limestones alternate with, and at one point are underlain by, hard flaggy ferruginous slates. Both the granites and limestones are cut by numerous dykes, which appear to belong to one period of eruption, but range from typical andesites and augite-porphyrites to a dark-green almost purely augite rock. A white or light-green dyke-rock is also common, composed almost entirely of epidote, zoisite, chlorite, secondary felspar and other alteration products. The granites opposite the upper end of Miles canyon are covered in places with basalts of the same age as those at the canyon and at White Horse rapids.

All the rocks mentioned above, except the basalts, have been affected in the mineralization of the district. The ore is seldom contained in well defined veins, but occurs as a rule scattered irregularly through wide zones and patches. These are often situated at the contact of the limestones and the granites, but are not confined to this position, as they occur frequently in the dyke-rock and occasionally also in both the granite and limestone. The most striking feature of the district is the great scale on which alteration of the country rocks has been carried on. In many places zones or irregular patches a hundred yards or more in width have been almost completely altered, usually into a garnet-rock holding bunches of epidote, actinolite and tremolite and ores of iron and copper. Some quartz is also usually present, but this mineral is not prominent. The alteration and replacement of the country rock and the attendant mineralization are evidently parts of the same process and have probably been produced in most cases by ascending heated waters charged with the required materials. Subsequent surface alterations of the ores from sulphides to carbonates and oxides, due to atmospheric agencies, are also conspicuous at most of the openings.

Among the prospects visited and hastily examined, are the Puebla, Rabbits Foot, Anaconda, Copper King and Carlyle near the northern end of the belt, the Valerie at the southern end, and the Arctic Chief, White Horse, Empress of India and Spring Creek claims at intermediate points.

The Puebla consists of a great mass of hæmatite of the specular variety, nearly fifty yards across, situated at the contact of the granite with the limestones and slates. The hæmatite is flecked all through with green copper-carbonate and in places with grains of bornite and grains and small bunches of chalcopyrite. The claim is opened up by a shaft 62 feet deep, and a drift from the bottom of the shaft 123 feet in length. The upper part of the shaft is in ore and the lower 32 feet in country rock. The drift reaches the ore 23 feet from the foot of the shaft, and is continued from that point through almost pure hæmatite. Near the end of the drift a second shaft has been sunk to a further depth of 25 feet, also through hæmatite. The lode at the shaft dips away from the granite at an angle of about 45°.

The origin of this great mass of hæmatite and included copper minerals is somewhat obscure, but it appears to belong to the class of replacement lodes. No well-defined walls, marked by fissures were anywhere noticed. On the contrary the ore passes gradually into the inclosing country rocks, although the latter are of several kinds. On the foot-wall the transition is from ore to altered granite, and on the hanging-wall from ore to slates and limestone. The replacement has been very complete, as only traces of the original rock remain in the main mass of the lode.

The Copper King lead follows a wide fine-grained dyke, the character of which has not been determined, traversing the granite in a northerly and southerly direction. The dyke contains a number of small limestone inclusions and is filled with secondary minerals, among which garnet and epidote are conspicuous. The lead has been opened up by a number of shallow pits, all of which show more or less ore, for a distance of 200 yards. The ore is not continuous on the surface and appears to be concentrated at points where cross fractures intercept the main lead, and at the limestone inclusions. At the principal workings a shaft 18 feet in depth has been sunk near the contact of one of those inclusions. The dyke-rock at this point is almost completely replaced by garnet and quartz impregnated with grains and bunches of bornite and chalcopyrite and occasionally with stibnite. The limestone to the east has also been well mineralized to a distance of twenty feet or more. A shipment of several car loads of ore which it is expected will run 14 per cent in copper will be made from this mine during the present winter. In addition to the copper contents, the ore is stated to carry some values in gold.

The Carlyle lead is situated about 300 yards east from the Copper King and is of a somewhat similar character. The workings consist of a shaft 50 feet in depth and a short drift along the lead. The ore consists principally of grains and bunches of bornite and chalcopyrite distributed through a gangue of garnet, quartz and country rock. The ore is banded in places.

The Anaconda and Rabbits Foot to the north of the Copper King have both been developed to some extent. The workings on the Anaconda consist of an open cut and a short tunnel. The lead cuts through granite, limestone and a fine-grained light-coloured dyke-rock, and is fairly well defined. It carries green carbonate of copper, bornite and chalcopyrite and is reported to yield fair values in gold. The Rabbits Foot follows along a fine-grained dyke cutting the granite and holding some limestone inclusions. The dyke has been altered in places into a mass of garnet, epidote, hornblende, etc., usually carrying more or less green carbonate of copper, bornite and chalcopyrite. In addition to the copper minerals erythrite or cobalt bloom was found at one of the openings. The workings consist of a number of shallow pits.

The Valerie is situated west of the head of Miles canyon. The lead occurs in a green basic dyke, consisting largely of augite, cutting limestone. The dyke has been mineralized in places for some width principally with magnetite and chalcopyrite. The chalcopyrite often occurs in bunches in the magnetite. A couple of surface openings and a shaft a few feet in depth constitute the workings.

The Arctic Chief, a couple of miles north of the Valerie, is situated in a wide porphyrite dyke cutting limestone and granite. The dyke-rock has been greatly altered and is now largely replaced by garnet, epidote, hornblende and other secondary minerals. Lenses of magnetite occur at several points. The largest of these has a width of fully 20 feet and carries chalcopyrite in grains, bunches and small veins. The workings consist of surface openings only.

The White Horse, to the south-west of the Arctic Chief, shows a fairly well defined lead 6 to 8 feet in width cutting granite. The gangue is more siliceous than usual and is heavily copper stained. The workings are confined to a single small surface cut.

The Empress of India is situated about a mile north of the Arctic Chief in a confused area of limestone, porphyrite and granite now altered and largely replaced by garnet, epidote quartz, calcite, hornblende and tremolite. The altered area is fully 150 feet in width and carries in places grains and bunches, some of considerable size, of bornite and chalcopyrite. The Spring Creek claim adjoining the Empress of India is similar in character. The work done on both claims is confined to surface openings.

In addition to the claims referred to above, a large number of others have been staked along the mineral belt, and on a few of them a small amount of development work, usually in the form of shallow surface cuts, has been done.

The district taken as a whole may be characterized as one of considerable promise, and as being well worth the attention of mining men. It is situated only 110 miles from the sea with which it is now connected by rail, and the expenses of mining need not be much greater than in the camps of southern British Columbia.

1901

Introductory Note

In 1901, the Director, Dr. Robert Bell, notes in his Summary Report for that year (page 6A):

"Mr. R. G. McConnell, assisted by Mr. Joseph Keele, worked in the Yukon district. Mr. McConnell's investigations were connected with the mode of occurrence of gold, both alluvial and in veins, and the investigation of new districts as well as those which he had visited in previous years. Mr. Keele was engaged during part of the time on an investigation of the copper deposits of the White Horse district, which were also visited by Mr. McConnell."

The following is McConnell's report on field work accomplished in 1901.

SALMON RIVER GOLD FIELD, INCLUDING LIVINGSTONE AND NEIGHBOURING PLACER CREEKS

by R. G. McConnell

During the past season the writer, assisted by Mr. Joseph Keele, who acted as topographer and geological assistant, was occupied principally in an examination of some of the smaller placer camps in the Yukon Territory. I left Ottawa on June 16, joined Mr. Keele, who had preceded me a few days, at White Horse on June 26, and after outfitting there, we proceeded at once to the Salmon river gold field. The party consisted, besides Mr. Keele and myself, of two camp hands, who were engaged at Sault Ste. Marie.

The Salmon river gold field is situated east of the South fork of the Big Salmon river. It can be reached by ascending the Big Salmon river to the South fork, a distance of about forty miles, and then continuing up the latter to the mouth of Livingstone creek, a further distance of about twenty-five miles. These streams are, however, swift and difficult to ascend, and the route generally adopted is to descend the Lewes to the mouth of the Teslin, and ascend the latter to Mason's Landing, a distance of about twenty miles. From Mason's Landing, a pack trail, fifteen miles in length, has been constructed across the ridge bounding the Teslin valley on the east, to the valley of the South fork of the Salmon, and branch trails continue on to the various creeks. The trail follows a wide depression in the ridge mentioned above, at the summit of which it reaches an elevation of about 1,700 feet above the Teslin valley. A wagon road, following nearly the same course across the ridge, could easily be constructed and would be a great boon to the district.

Topography

The topography of the district is simple. A ridge about five miles in width where crossed by the trail, separates the Teslin river at this point from the valley of the South fork of the Salmon. The ridge is traversed by several deep depressions and is fairly regular in outline as a rule, but in places is surrounded by rocky peaks, some of which attain an elevation of 5,000 feet.

East of the Teslin ridge is the great valley of the South fork of the Salmon, a huge depression some thousands of feet in depth, and where crossed by the trail, nearly two miles in width. The valley-bottom consists of a wide, partly forested gravel plain, broken in places by low benches and terraced along the sides up to an elevation of about 500 feet. The South fork itself is a shallow stream, seldom exceeding thirty yards in width, flowing rapidly along a boulder-paved channel. It rises in a range of granite mountains to the south and has a length, measured along the valley, of about sixty miles. Its grade at the mouth of Livingstone creek averages forty-five feet to the mile.

The valley of the South fork is bordered on the east by a steep slope, about 2,000 feet in height, beyond which is a strip of plateau-like country, four to five miles in width, surmounted by low rounded hills, the summits of which have an elevation of from 2,000 feet to 2,500 feet above the valley. The plateau-strip is terminated on the east by a high mountainous district, worn into sharp peaks and bold projections, on some of which the snow lies throughout the season. The plateau-strip bordering the valley constitutes the gold field of the district. The larger creeks cut back through it into the high mountain region beyond; the smaller ones rise in the lower foreground and descend rapidly, often in a series of cascades, to the level of the valley of the South fork.

The valleys and the slopes of the plateau, up to a height of about 2,000 feet above the valley of the South fork, are partially forested. The principal trees noted were the Banksian pine, the white and black spruces, the aspen, the rough-barked poplar, the balsam fir and a species of birch. The trees, as a rule, are small and the quantity of serviceable timber in the immediate vicinity is limited. A few groves of white spruce were noted, some individuals of which attained a diameter of fully eighteen inches, but trees of this size are rare.

Geology

The geology of the district can only be briefly referred to here as the rocks have not been studied. The oldest beds in the district consist of hard micaceous quartzites, passing into mica-schists. These rocks are exposed along the eastern slope of the mountains referred to above, as bounding the auriferous plateau on the east. They are interbanded towards the top with crystalline limestones and are overlaid by green chloritic schists, probably representing crushed diorites or diabases. The green schists are followed in ascending order by gray quartz-biotite schists, white and light gray sericite schists, resembling the gold-bearing schists of the Klondike series and probably like them of igneous origin, lead-coloured argillites, a second series of green rocks, mostly tuffs, above which is a wide band of hard cherty limestone forming the western edge of the plateau. The schists and associated quartzites and limestones have a nearly north and south strike and dip steadily to the west at angles of from 20° to 50°.

The high narrow plateau bordering the valley of the South fork on the east, in which most of the gold streams of the district have their sources and which all of them traverse, is thus seen to be built almost entirely of micaceous schists of various kinds, and from these rocks the gold of the district undoubtedly originated. The schists are partly of igneous and partly of clastic origin and resemble in a general way the gold-bearing schists of the Klondike district.

The ridge between the South fork of the Salmon and the Teslin rivers is built of comparative recent volcanic rocks consisting largely of andesites, augite-porphyrites and allied varieties. Basalt occurs at the base of the western slope, and tuffs and agglomerates on the eastern slope.

The schists east of the South fork are cut, south of Mendocina creek, by some dykes and a couple of small bosses of gray biotite granite. This rock is not conspicuous in the district, but is apparently widely distributed further to the south, as the wash in the South fork is largely granitic.

Gold-bearing Streams

Gold has been found in some quantity on all the streams traversing the high plateau, previously described as occurring east of the South fork, along a stretch about twelve miles in length extending from Sylvia creek to Mendocina creek. The schists which underlie this portion of the plateau continue on both to the south and to the north and it is probable that the field will be extended as prospecting continues.

The most productive stream so far discovered is Livingstone creek. This creek has a total length of ten miles. Its general course is westerly, but four miles above its mouth it enters an old longitudinal valley which cuts off a segment of the plateau, and turns abruptly north for two miles before crossing the flats to join the South fork. It is a fair-sized stream, measuring about fifteen feet in width at ordinary stages of the water, where it leaves the hills. The current is very swift, as the grade is steep, exceeding 400 feet to the mile in some places.

The valley of Livingstone creek differs considerably in character from that of the Klondike creeks. In its upper part, it is a deep, rounded depression, evidently modified by glacial action, terminating in a steep-sided amphitheatrical basin. Farther down, the valley narrows in and becomes a canyon bounded by steep rocky walls separated at their bases by a narrow flat from 50 to 100 feet in width. The canyon portion of the valley has a length of about three-quarters of a mile and ends abruptly at the old valley previously referred to, which the creek enters after leaving the plateau.

The workings on Livingstone creek so far have been confined principally to the canyon portion of the valley. Discovery claim, on which the most work has been done, is situated near the head of the canyon. The gravels here and along the canyon generally are quite shallow, seldom exceeding three feet in depth, and in places the bed-rock is bare. They are, unlike the Klondike gravels, only partially derived from the rock exposed along the valley, and include much foreign glacier-borne material, largely of a granitic character. Boulders are numerous and are often of large size, some of them measuring six to eight feet or more in diameter. The heavy grade of the valley renders hydraulicking practicable, and on Discovery claim the water is flumed along the bank until a head of about fifty feet is gained and it is then used to ground-sluice the light wash in the bed of the stream. The heavy boulders are removed, when necessary, with a derrick.

The gold is found principally on bed-rock or in the crevices of the rock and as a rule is very coarse. A third of the gold obtained from Discovery claim consisted of nuggets over an ounce in weight, and none of it, I was informed by the manager, could be called fine gold. The largest nugget obtained was valued at $304, and the second largest at $295, assuming the gold to be worth $16 to the ounce, the ordinary price. The assay value of the gold is stated to average $18.20 to the ounce. A few of the nuggets show a rough surface and include fragments of quartz, but as a rule they are worn quite smooth. This is probably due largely to the attrition of the sediment in the stream, as it is impossible that gold of this character could have been carried for any considerable distance.

Discovery claim is stated to have produced $11,000 in 1900, and a small amount in the preceding year. The product of the present season was not ascertained, but the 'clean up' which was made at the time of my visit was very satisfactory and the output for the season will probably be considerable. The ten claims below Discovery claim and extending from it down to the foot of the canyon are very similar in character to Discovery claim. They are owned by a company and preparations are being made to work them on an extensive scale during the coming season.

Very little work has been done on Livingstone creek above the canyon, as the ground is much more difficult to prospect. The gravel is much deeper, and as it is not frozen except in sheltered spots, work on the shafts has mostly been stopped before bed-rock was reached by the inflow of water. The claims will require to be drained before they can be worked and this can only be done by a company owning several of them, or by a number of the claim owners combining and working their properties in common.

Below the canyon, the creek, as stated before, enters an old valley and runs for some distance at right angles to its former course. The gravel in this portion of the valley proved to be very deep. A number of shafts have been sunk, one of them to a depth of over seventy feet, without reaching bed-rock. Work on most of these shafts was stopped by water before any results were obtained.

Summit creek, two miles north of Livingstone creek, and running parallel with it, is a much smaller stream, scarcely measuring six to eight feet in width where it leaves the hills. It heads in the plateau and, after a course of less than three miles, cascades down into a longitudinal valley, which here follows the base of the hills and runs north to Cottoneva creek. Its valley, where it leaves the hills, is narrow and canyon-like in character, but above the cascade it gradually widens out and assumes the form of a broad rounded and comparatively shallow depression.

Discovery claim, on this creek, is situated at the foot of the cascade. The gravels here are shallow and include, as on Livingstone creek, numerous granitic boulders. The claim is worked by ground-sluicing, water for this purpose being easily and cheaply obtained from the cascade. About $1,200 was taken out in 1900. The gold is similar in character to that from Livingstone creek. The claims above the cascade have not been prospected, although some work has been done. The gravels deepen rapidly in ascending the valley, and work on the few shafts which have been started, has been stopped by water before bed-rock was reached.

Lake creek, a mile north of Summit creek, is about equal in size to the latter and its general character is very similar. Discovery claim on this creek, is situated above a cascade, which occurs, as on Summit creek, near the brow of the plateau. The gravels at this point, and for a few claims above, are comparatively shallow, averaging from four to eight feet in depth and can be easily worked. Work had only begun at the time of my visit, but some gold was being taken out and the miners appeared to be very hopeful in regard to the future of the creek.

Cottoneva creek, three miles north of Lake creek, is a much larger and longer stream and it has cut a more uniform grade down from the plateau.

A canyon, half a mile in length, occurs about a mile from the point at which it leaves the hills. Above the canyon the valley is wide with gently sloping banks. The first discovery in the district was made on this creek in 1898, but the yield has been small and at the time of my visit no work was being done. The gravels are reported to be deep and difficult to work above and below the canyon, and in the canyon, where they are shallow, they do not appear to be productive. Besides the creeks briefly described above, good prospects have been obtained from Martin and Sylvia creeks, south of Livingstone creek, and from Little Violet and Mendocina creeks north of Cottoneva creek, and on the opposite side of the valley some work was being done near the mouth of St. Germain creek, a stream heading in the range west of the South fork.

The total production of the Salmon river gold field up to, but not including the present season, was estimated at $20,000, the greater part of which has been obtained from Discovery claim on Livingstone creek. Work in the district has, however, barely commenced, notwithstanding the fact that gold was discovered as early as 1898. The field can only be considered of moderate richness and the fame of the Klondike creeks drew most of the miners to that section. The outlying camps are now, however, receiving more attention and it is expected that work in the future will be more vigorously prosecuted.

Yukon River, from Fort Selkirk to Stewart River

After leaving the Salmon river gold field we descended the Lewes and Yukon rivers in a Peterborough canoe, and a few days were spent in making an examination of the geological section exposed along the Yukon valley below Fort Selkirk. Only a brief reference to this work will be made here. The rocks at Fort Selkirk and down the Yukon valley for fifteen miles consist mostly of diabases, coarse tuffs and agglomerates. These rocks are underlaid by a highly altered clastic series consisting largely of quartz-mica-schists, quartzites and crystalline limestones. The clastic series, in a more or less altered condition, occurs at intervals along the valley down to the mouth of Forty-mile river and probably beyond. It alternates in broad bands with igneous schists and gneisses, derived mostly from granites, quartz porphyries and diorites. The granite gneisses have been regarded as the oldest rocks in the Yukon valley, but positive evidence was obtained during the course of the exploration that they are really younger than the altered clastic series and have been intruded through them. The old igneous schists, and to a less extent the clastic schists, are very important from an economic standpoint, as they constitute the gold-bearing rocks at all the camps so far examined. They are broken through at numerous points along the valley by intrusives of various kinds and are overlaid in places by more recent rocks, but a description of these does not come within the compass of this report.

Thistle Creek

Thistle creek enters the Yukon from the east about eight miles above the mouth of White river. It is about eighteen miles in length and towards the mouth from fifteen to twenty feet in width. The valley is flat-bottomed in the lower stretches, the flats varying in width from 150 to 400 yards, but towards the head it narrows into a V-shaped gulch. The bordering hills have a general height above the valley of 1,000 feet to 1,500 feet, but in places slope up to sharp peaks and ridges very much higher. Terraces occur at intervals, but do not form continuous lines. The grade of the valley increases gradually towards the head. Six miles above the mouth it amounts to 50 feet to the mile, and at twelve miles to 100 feet to the mile.

Discovery claim on Thistle creek is situated about six miles above the mouth. The creek was staked in 1898, but the work done on it up to the present has been inconsiderable. At the time of my visit some work, chiefly of a prospecting character was being done on claims 17 and 19 below and 9 above Discovery on a terrace opposite 9 above, and at the mouth of Edas gulch which comes in opposite 12 below. The gravels on Thistle creek resemble those on the Klondike creek. They consist principally of flat schistose pebbles, imbedded in coarse sand, and include occasional boulders of quartz and granite. They have a thickness in the vicinity of Discovery claim of from four to six feet and are overlaid by a layer of muck, usually from 8 to 10 feet in thickness. The terrace gravels are coarser than those in the creek and have a thickness at the rim of the bench opposite Discovery claim of 25 feet.

None of the Thistle creek claims yet worked have proved very rich. The gold is irregular in its distribution and so far has been found principally along the left limit of the valley close to a well defined terrace which extends from claim No. 9 above Discovery down stream about three miles. The gold is found principally on or in bed-rock and occurs in coarse grains and nuggets. The largest nugget reported came from claim No. 1 above Discovery and was valued at $96. The total product of the creek is estimated at $10,000.

Henderson Creek

Henderson creek enters the Yukon from the east about three miles below the mouth of the Stewart. It is a longer stream than Thistle creek and carries considerably more water, but is very similar in general character. It occupies a flat-bottomed valley of the usual type, bordered by fairly steep, mostly wooded, banks which are, in places, interrupted by irregular disconnected benches, but the banks are not conspicuously terraced.

The rocks exposed along the valley consist, as on Thistle creek, mainly of granite-gneisses and other igneous schists. At the Forks, three miles above the mouth, inliers of white crystalline limestone associated with quartz-mica-schists and quartzite were noticed, and andesites occur in a group of high rounded hills near the head of the creek.

Only one claim was being worked on Henderson creek at the time of my visit. The creek was hurriedly and inadequately prospected in 1898 and since then has been practically abandoned. The claim which is being worked is situated about fourteen miles above the mouth of the creek and just below the junction of the main branch with Sixty-mile creek. It is owned by two Australian miners who have worked it partly by drifting and partly by the open-cut method for several seasons, and are apparently quite satisfied with the result. The gold is finer than on Thistle creek and is not concentrated near bed-rock, as is the case on that creek, but extends, like the Bonanza creek gold, upwards into the gravels for several feet. It is unlikely that this claim is the only one containing pay gravel in this portion of the valley and systematic prospecting on some of the adjoining claims would probably lead to equally good results.

Sixty-Mile District

The gold creeks of the Sixty-mile district are situated near the Alaskan boundary, about forty miles directly west from Dawson. They can be reached by ascending Forty-mile river, a western tributary of the Yukon, to the mouth of Moose creek a couple of miles west of the International boundary, from which point a good trail about twenty miles long leads to the principal creeks; or by a pack trail from Dawson, 56 miles long which follows the divide between Swede creek and the Yukon, or by ascending Sixty-mile river. The latter route is seldom used, owing to the shallowness of the stream, and the numerous bars and rapids which interrupt its course. All these routes were traversed in the course of the present exploration. The writer reached the district by Forty-mile river and the Moose creek trail, and descended Sixty-mile river on the way back in a small canvas boat which was portaged across from Forty-mile river for the purpose, while Mr. Keele travelled by the overland route and made as careful a survey of it as time permitted.

Geology

The rocks in the Sixty-mile district are similar to those occurring on the Yukon valley above Dawson. The beds have a general east and west strike, and a section across them from Forty-mile river south to the Sixty-mile shows two broad bands of dark quartz-mica schists, quartzites and crystalline limestones, similar to the rocks described by me in a former report as the Indian river series, separated by a band of igneous schists four to five miles in width. The latter consist partly of gray granite-gneiss, and partly of light-coloured sericite schists derived mostly from quartz-porphyries. The schists are replaced near Sixty-mile river by andesites and are overlaid on Moose creek by a small area of conglomerates, probably of Cretaceous age.

Gold-bearing Creeks

Coarse gold was discovered in the Sixty-mile district in 1893, and from that time up to the discovery of the Klondike creeks in 1896, it was one of the principal producing camps in the Yukon country. It was practically abandoned in 1897, but lately the miners have been returning to it. At the time of my visit, about forty men were at work.

The principal creeks are Miller and Glacier* creeks on the Sixty-mile slope, and Moose creek, a tributary of Forty-mile. Moose creek is a large stream, about twenty feet wide at its mouth, and about fifteen miles in length. Its valley is about 200 yards wide in the lower reaches, but gradually contracts towards its head into a narrow gulch. Gold in small quantities is found all along the valley, but only a short stretch, barely a mile in length, commencing about ten miles above its mouth, contained claims rich enough to work. The gravels had a depth of from two to four feet, and the gold occurred in a narrow pay streak in the centre of the valley. The total amount produced is given at $5,000 only.

Glacier creek is a tributary of Gold creek, and joins the latter a mile above its mouth. It is a small stream, from two to three yards in width, and less than seven miles in length. The grade is steep, amounting to about 100 feet per mile in the lower part of the valley, while further up it becomes

* A detailed description of Miller and Glacier creeks, by J. E. Spurr, is published in the eighteenth Annual Report of the U.S. Geological Survey, pp. 320-326.

much steeper. The valley conforms to the usual type. The upper part is a narrow gulch, but in descending, it gradually widens, and towards its mouth has a breadth of 200 yards. It has been worked from claim No. 28, above Discovery, down almost to its mouth, a distance of about five miles. The pay streak from No. 21 above, down to No. 17 above, is reported to have been very continuous but quite narrow, less than twenty feet in width. Farther down it widened out and became more spotty. Claim No. 18 below is stated to have been the best claim on the creek. The valley gravels have a thickness of from six to ten feet and are overlaid, as on the Klondike creeks, by a varying thickness of black muck. They have been mostly worked over, but a few claims, too low in grade to pay in the early days, still remain, and some gold was also being obtained from a few of the richer claims which had been imperfectly or only partially worked.

The terraces on Glacier creek were neglected up to the last year or two, but are now being worked at several points. Well defined benches occur on the left limit, opposite claims 10 and 12 above, and on the right limit opposite No. 6 below and down the valley for some distance farther. The bench opposite No. 10 above, is interesting in as much as the workings, consisting of three shafts, one 62 feet deep, prove the existence of an old channel, separated from the present creek channel by a rock ridge 27 feet high and about 200 feet in width. The old channel has an elevation of 75 feet above the present one. Pay was found in one of the shafts, and the owners expect to work the claim from a tunnel which they are driving through the rock ridge. At claim No. 6 below, good pay has been struck on a terrace on the right limit 40 feet above the valley bottom. The gravels here have a thickness of about 50 feet.

The terrace gravels of Glacier creek are ordinary stream wash, deposited before the valley had been sunk to its present depth, and they have no resemblance to the enigmatical quartz drift or white wash of Bonanza and Hunker creeks.

Miller creek, west of Glacier creek, empties into Sixty-mile river. It is somewhat shorter than Glacier creek, about equal to it in size, and its general character is very similar. Miller creek was considered a very rich stream in early days, and for two or three years after its discovery, it ranked as the chief producer in the Yukon country; but it is now nearly exhausted so far as the valley gravels are concerned. Terraces occur on the left limit from No. 2 below, down to about No. 20 below. They were only discovered recently and are still practically unworked. A terrace claim opposite creek claim No. 17 below, is stated to have yielded $18,000 during the past season. The terrace here has an elevation of fifty feet above the creek bottom and the gravels have a thickness of about fifteen feet near the rim, but evidently deepen considerably, farther back.

Other creeks in the district are Poker and Davis, both of which head in the Yukon territory, but have their principal productive portions in Alaska; and Gold creek, Twelve-mile creek and California creek, tributaries of Sixty-mile river from the north, all of which show prospects, but up to the present have afforded no paying claims. The total production of the Sixty-mile creeks is difficult to estimate at this late date, but was probably less than half a million dollars.

The gold on Miller and Glacier creeks is derived, in large measure, directly from the quartz veins and silicified schists of the district, but some evidence was obtained in the course of the exploration, serving to show that some of it has been deposited from solution. A boulder was found in one of the workings on Miller creek, the upper surface of which was partially covered with specks and scales of crystalline gold. The crystals were arranged in dendritic forms, and while some of them were firmly attached to the rock, others separated easily from it. The angles of the crystals were sharp and showed no wear of any kind, while the boulder itself, an autoclastic quartz-mica schist, was well rounded. The gold evidently did not belong to the rock originally, and the only explanation of its occurrence under the peculiar conditions stated, seems to be, that it was taken up by some solvent and redeposited on the surface of the boulder in the position in which it was found. A number of specimens of unworn crystalline gold in filiform and dendritic shapes have been found on Eldorado and other Klondike creeks, which were probably formed in the same way, although no direct evidence of this has hitherto been obtained.

Sixty-Mile River

A track-survey was made down Sixty-mile river from the International boundary to its junction with the Yukon. This stream heads in Alaska and has a length, after crossing into Canadian territory, measured along the valley, of about 70 miles, and following the windings of the stream, of about 125 miles. Its fall, measured roughly with the barometer, from the boundary to the Yukon, amounts to 1,425 feet, and the average grade of the valley to a little over 20 feet to the mile.

Sixty-mile river, at the Boundary, is a rapid winding stream averaging about 50 feet in width and interrupted at frequent intervals by steep bars covered with only a few inches of water. The upper portion of the river from the Boundary to California creek can hardly be considered a navigable stream even for small boats. Below California creek the volume of water increases and the descent becomes less difficult, but bars and rapids continue almost to the mouth and no part of the river is easy to ascend. The tributary streams are small, as a rule, but two large streams, one draining the country to the west and the other to the south, come in within four miles of each other, nearly opposite Indian river and these branches nearly double the volume of the main river. Towards its mouth Sixty-mile has an average width of from 40 to 50 yards.

The valley of Sixty-mile is generally flat-bottomed, the flats varying from a couple of hundred yards to nearly a mile in width. The sides are usually terraced and in places, the stream for long distances, has cut a secondary rock-walled channel, similar to that noticed on Indian river and the Stewart, through the bottom of its old valley. The country bordering Sixty-mile river forms part of the Yukon plateau, a highland worn into rounded hills and long zigzag ridges, but containing no well defined and continuous mountain ranges. At several points, high hills usually built of andesite, project a few hundred feet above the general level.

Sixty-mile river affords a very good geological section, but only the salient points of this can be given here. At the Boundary and down the valley to Bed-rock creek, the rocks consist principally of igneous schists of various kinds, largely granite-gneisses, with which are associated some quartzites and other clastic schists. These schists constitute the gold-bearing rocks. They are replaced below Bed-rock creek by andesites which continue down to a point a mile and a half below the mouth of Gold creek. The andesites extend up Miller creek nearly three miles and up Gold creek over seven miles. Their distribution south of Sixty-mile river is not known, but they apparently cover a considerable tract of country in that direction.

Below Gold creek the granite gneisses and associated igneous and clastic schists reappear and are exposed along the valley down to a point five miles below the mouth of Ofa creek. The schists, in this stretch, are cut by numerous intrusions of newer granite, and quartz veins are fairly abundant. They are succeeded by andesites, basalts and other volcanics, and these rocks, alternating with basins of sedimentary strata consisting mostly of conglomerates, agglomerates and shales, probably of Cretaceous age, continue down the valley for twenty miles. Below that point the granite-gneiss and included clastic schists and crystalline limestones appear again and outcrop along the valley down to the mouth of the river. The gold-bearing rocks, it will be seen, occupy the upper and lower parts of the valley but are covered up along the central portion by more recent and, so far as known, barren rocks. Some bars were worked in early days on Sixty-mile river, but so far as could be learned, none of them proved very rich and at the time of my visit no work of any kind was being done.

Quartz Veins

Considerable prospecting for quartz has been done in the Klondike district and in other parts of the Yukon country during the past season, and numerous discoveries of more or less importance have been reported. The old igneous and clastic schists referred to previously as the gold-bearing rocks and which have such a wide distribution along the Yukon valley, are cut everywhere by quartz veins and in places these become so abundant as to constitute a considerable proportion of the whole rock-mass. The majority of the veins follow the planes of schistosity or cut them at a small angle. They are narrow and non-persistent as a rule, but occasionally swell out into lenses of quartz six to eight feet or more in width. These veins often give fair assays and in places show free gold, but except in rare instances they are too small singly to make mines. The discovery of a zone of small auriferous quartz veins closely grouped together, and capable of being worked together, is however possible, and in a region so highly silicified as the Klondike district, even probable.

Before leaving Dawson, a visit was made to the New Bonanza and Lone Star claims at the head of Victoria gulch, a tributary of Bonanza creek. The development work done on these claims consists of a few shallow shafts or pits, none of which reach any considerable depth. At one of these openings on the New Bonanza, a kidney of quartz, over six feet in width has been uncovered for a few feet, one end of which is studded with grains and nuggets of gold. A second opening, 200 feet to the south-east, has been sunk in a smaller quartz vein, also carrying free gold. A specimen of quartz from this vein, in which no free gold could be detected with the naked eye or an ordinary magnifying glass, was assayed in the laboratory of the Survey and gave 2·625 ounces of gold and 3·267 ounces of silver to the ton. The country rock, mostly sericite schists, adjoining the vein, also proved to be auriferous. Other small veins occur to the north-west, following the same south-east and north-west strike as those above mentioned. The work done on these claims is insufficient to base an opinion on as to their ultimate value, but the prospects are certainly encouraging enough to warrant further investigation.

The existence of a group of quartz veins at the head of Victoria gulch, carrying free gold in such quantities, is interesting from the fact that the pay streak on Bonanza creek practically stops at the mouth of this gulch. Victoria gulch itself is gold-bearing, and the gold obtained near its head is rough and unworn and looks as if it had just dropped out of its original matrix. It is not inferred from this, of course, that all the gold on Bonanza creek originated from this source, as the coarse gold found along this stream could not have travelled any distance, but that some of it came from this point seems beyond question.

Quartz veins are prominent in places along Sixty-mile river and a couple of specimens collected proved to be auriferous. A vein about four feet wide cuts the granite-gneisses about a mile below Twelve-mile creek, in the upper portion of the river. A specimen from this vein was assayed in the laboratory of the Survey and yielded 0·058 ounces of gold to the ton. A vein was also found about six miles above the mouth of the river, on a bluff 200 feet above the level of the valley, a specimen from which assayed 0·117 ounces or nearly $2.50 to the ton. This vein consisted of light brown drusy quartz and at the point examined it was fully eight feet in width. It apparently belongs to a different class from the ordinary small gash veins of the district, and is worth a closer examination, as the proportion of gold usually varies along the strike and portions of this vein may be rich enough to work.

Quartz veins occur in the schists of the Salmon river country, but the only specimens assayed from this district proved to be barren. Specimens from a vein on Fish creek, a tributary of the South fork, which carried iron and copper pyrites and galena were shown to the writer. The vein is stated to be of large size, but it was not examined.

River Dredging

The dredging operations at Cassiar bar, on the Lewes river, in 1900 proved a failure. About 50,000 cubic yards of gravel were washed, and the average yield, so I was informed by one of those interested, averaged only five cents per cubic yard. The bar has been abandoned and the plant transferred to a claim on Bonanza creek, where it is reported to be doing satisfactory work. Cassiar bar was worked in early days by the miners, and was supposed to offer exceptional facilities for dredging. The failure there has, on this account, led to an impression that a like result would attend dredging operations in any part of the district. This opinion, it seems to me, is not well founded. Cassiar bar is situated a long distance from the source of supply and, as a consequence, the gold is very light, and is confined, as is usual in such circumstances, to a thin layer of gravel immediately beneath the surface. The conditions are entirely different on streams or portions of streams, near to, or cutting the rocks from which the gold originates. The grains in the latter case are heavier, are less easily moved, and the gravels increase in richness, as a rule, towards bed-rock. The bars on Forty-mile river, a stream cutting the gold-bearing schists throughout nearly its whole course, afford a good example of this. The gold on the auriferous bars on this stream is much coarser than that obtained from Cassiar bar and the best pay occurs near bed-rock. The gravels on the Klondike river below the mouths of the gold-bearing creeks has been proved to be auriferous to some extent down to bed-rock, and gold, in grains much coarser than the ordinary flake gold of river-bars, has been found in the bed of the Stewart, and also on the bars of the Big Salmon. Whether dredging would pay on any of the streams mentioned, is a question which can only be answered by careful prospecting or actual work, but it is obvious that the result of a single experiment cannot be accepted as settling the matter in the negative for the whole district.

1902

Introductory Note

The following note is by Dr. Robert Bell, Director, on field work for 1902*:

"The most northerly expedition was that of Mr. R. G. McConnell who, with Mr. Joseph Keele as assistant, made an instrumental topographical survey and a geological reconnaissance of Macmillan River, a stream nearly as large as the Ottawa, which falls into the Pelly from the east, a short distance above the point where the latter joins the Lewes to form the Yukon. On reaching the forks of the Macmillan the instrumental survey was discontinued and McConnell explored the northern branch, while Mr. Keele traced the southern. In addition to the work done along the main river and its branches, the hills and mountains on either side were ascended at frequent intervals for the purpose of examining the rocks. It was found that from the mouth of the river to the highest points reached, the main stream and both its branches flowed over crystalline rocks, mostly altered sediments. Samples were collected from a number of quartz veins and it was hoped that some of these would be found to contain gold, but on assay in the laboratory of the Survey, none was detected. The results of the above work are, therefore, valuable principally on account of the new topography and geology acquired, as well as the general information in regard to the nature of the country through which the Macmillan River flows."

THE MACMILLAN RIVER

by R. G. McConnell

The work during the season of 1902, consisted in making an examination of the Macmillan river, one of the principal feeders of the Pelly. I left Ottawa on the 7th of June, accompanied by Mr. Joseph Keele, and reached Whitehorse, where we outfitted, on the 17th of June, and Fort Selkirk at the mouth of the Pelly, on the 22nd. Two days afterwards we proceeded up the Pelly river, carrying our summer supplies in two Peterborough canoes which we had brought with us from Ontario.

The party consisted of Mr. Keele, who acted as topographer and assistant geologist, the writer, and two canoemen from Sault Ste. Marie. We were delayed on the Pelly by the flooded condition of the river, the highest rise of the season occurring on June 29, and did not reach the mouth of the Macmillan until July 5.

The early part of the season was occupied in making a traverse by micrometer up the Macmillan to the forks, a distance of about 150 miles. The micrometer traverse was afterwards continued by Mr. Keele up the South fork for a further distance of fifty miles. The North fork proved to be an exceedingly rapid stream, very difficult to ascend, and as time was limited and it was important to explore both branches, Mr. Keele was directed to survey as much of the South fork and its tributaries as possible, while the writer continued on up the North fork. This was ascended to a point a few miles above Cache creek, and then the latter stream was followed to its head. We had been informed that it headed with Peel river, but this proved to be incorrect. The valley occupied by Cache creek connects the

*Sum. Rept., 1902, in Ann. Rept., vol. XV, p. 12A (1906).

Macmillan with the South fork of the Stewart, and from the top of a mountain at its head, which was ascended, the valley of the Stewart could be traced at least thirty miles in a north-easterly direction. The head of Cache creek, the farthest point gained, was reached on August 12, and on the 13th we commenced the return journey. A number of mountains had been selected for climbing on the way up, and stoppages of from one to three days were made at those points on the way down. A micrometer traverse was also made of the Pelly from its junction with the Macmillan to Fort Selkirk at its mouth.

General Description

The Macmillan river has a total length of about 285 miles. It divides at 150 miles above its mouth into two nearly equal branches, known as the North and South forks. The North fork carries the most water, and has a length of about 135 miles. The South fork is probably of nearly equal length.

The main river, in its lower reaches, is a winding stream varying in width from 300 to 500 feet. The current is sluggish, seldom exceeding, in the first fifty miles, a rate of three miles an hour. The valley has a width of from one to five miles or more and is covered with a heavy deposit of clays, silts, sands, gravels and boulder clay. The river has cut a great trench in these deposits usually about 200 feet in depth, and from one mile to two miles in width, and now winds from side to side of this depression, occasionally cutting into and destroying portions of the bordering banks. In the lower portion of the river the cut banks consist largely of a bluish plastic clay, and at several points great masses of this material have slidden forward and in some instances formed barriers extending nearly across the river. The drift plain bordering the river banks is bounded on both sides by ranges and groups of hills and mountains, rising from 2,000 feet to nearly 5,000 feet above the level of the valley.

The easy current characteristic of the lower portion of the Macmillan is interrupted about fifty miles above its mouth, by a stretch of comparatively rapid water five or six miles in length, above which the current is again generally slack for a further distance of fifty miles, although a few riffles occur. In the upper fifty miles, the current becomes much swifter, flowing at a rate of from three to five miles an hour. The swiftest stretches occur at places where the stream has recently broken through the necks of ox-bow bends, and so shortened its course. The greater portion of the river is easily navigable, except at low water, by small steamers.

The principal difficulty occurs at Porphyry bluff. The river at this point runs swiftly around a number of sharp bends and the channel is filled with snags. The latter could easily be removed if necessary. The grade of the Macmillan was estimated at from one to two feet per mile in the lower portion of the river and from two to four feet in the upper portion. The average grade throughout, probably amounts to about three feet to the mile and the total fall from The Forks to the Pelly is estimated at 450 feet.

The principal feeders of the Macmillan below The Forks are Kalzas river, Moose river and Russell creek. The streams are all northern tributaries, no important feeders entering the river from the south. Kalzas river, which joins the Macmillan twenty-seven miles above its mouth, is a large rapid stream about sixty feet in width. It forks a short distance above its mouth, the principal branch occupying a wide terraced valley, which extends in a north-easterly direction for a distance of about forty miles. The northwesterly branch empties Kalzas lake, a sheet of water about six miles in length, lying behind the Macmillan mountains. This branch follows part of an old valley, which has been traced from the Pelly, in a north-westerly direction to the Klondike and beyond. This valley is occupied in different parts of its course by a portion of the Pelly, a branch of Kalzas river, Crooked creek, a portion of the Stewart river, Clear creek, Flat creek, and the lower part of the North fork of the Klondike river. This ancient drainage channel is an important topographical feature of the country, and may prove to be of economic value, as gold may be concentrated in portions of its course. It runs in a north-westerly direction, crossing the present main drainage channels diagonally, and has a width of from two to ten miles or more. In the glaciated area, it is bordered by wide terraces built up of silts, sands, gravels and boulder clay, and in the unglaciated area, north of the Stewart, it is filled to a depth of at least 600 feet with sand and gravel.

Moose river, which enters the Macmillan about midway to the Forks, also occupies an old valley which extends in a north-easterly direction to the South fork of the Stewart, but has not been traced beyond. Moose river is a winding stream about 50 feet in width having a length measured along the valley of about eighteen miles, but following the windings of the stream it is fully twice this distance. It is the outlet of Moose lake, a body of water about eight miles in length occupying a depression in the floor of the old valley.

Russell creek (Red Slate creek) joins the Macmillan about four miles below the Forks and is important as being the only tributary, so far, on which coarse gold has been found. It heads in a small lake 12 miles north of the Macmillan, and has a total fall of 1,400 feet. It is a rapid stream about 40 feet in width and is fed by a number of impetuous torrents descending from the mountains bordering its valley. The valley of Russell creek is from one to three miles in width and extends through to the Stewart drainage system.

Recent elevation in this valley is shown by the fact that the present stream has cut in places a canyon in the bottom of the old channel.

Topography

The general character of the country in the vicinity of the Macmillan is mountainous, although the ranges as a rule are isolated by wide valleys and depressions. Below Kalzas river the Macmillan is bordered on the north by the Macmillan mountains; a long ridge with fairly even slopes except near the centre, where it rises about 1,000 feet above the tree line and is broken into a number of rocky peaks, the highest of which has an elevation of about 3,800 feet above the level of the river or 5,600 above the sea. Opposite the Macmillan mountains the country between the Macmillan and the Pelly is occupied by a high plateau-like mass with smooth outlines, the summit of which rises just above the tree line to an elevation of about 2,700 feet over the valley. East of this plateau is a wide depression, extending east to Dromedary mountain and south to the Pelly. This depression is faced on the north of the Macmillan by Kalzas mountain and the range connected with it. Kalzas mountain rises 4,300 feet above the valley and is the highest peak along the main Macmillan river. Northeast from it, at a distance of ten miles, is Clarks peak, a conspicuous conical mountain, visible from almost every elevation climbed to, along the river.

The region north of the Macmillan, between the valley of Moose river and Russell creek, is occupied by a high broken plateau, deeply trenched by numerous streams flowing into the surrounding valleys. South of the Macmillan the country bordering on the valley, with the exception of a couple of relatively unimportant depressions, is rough and mountainous from Dromedary mountain east to the Forks. The mountains, mountain groups, and broken uplands along the Macmillan valley have a common origin and may be briefly described as representing surviving fragments of an extensive highland, the major portion of which has been destroyed by sub-aerial denudation and erosion.

The North Fork

The Macmillan, a few miles above Russell creek, separates into two branches known as the North and South forks. The two branches are nearly equal in size, but the former carries a much larger volume of water. The North fork, although it continues for some miles in the same direction as the main Macmillan and occupies a similar wide flat bottomed valley, differs entirely in character.

It is an exceedingly rapid stream and bears more resemblance to a mountain torrent than to an ordinary river. Between the Forks and Cache creek, a distance of 45 miles, measured along the valley, and about 70 miles following the windings of the river, the former has a fall of about 18 feet to the mile and the river of about 12 feet to the mile. The current is uniformly swift throughout, running at the rate of from five to eight miles an hour. The channel in places is filled with boulders, and strong riffles are frequent, especially for some miles above and below the mouth of Husky Dog creek, but no strong rapids necessitating portages occur below Cache creek. Two and a half miles above this is the Big Alec rapid, a rough bed-rock rapid a quarter of a mile in length. Above this rapid the stream continues very swift as far as examined.

The direction of the North fork is generally a few degrees north of east, except in one stretch 10 miles in length commencing 25 miles above its mouth measuring along the valley. The river at this point enters an old valley running nearly magnetic north and south and follows it north to the mouth of Husky Dog creek, then leaves it abruptly and continues its easterly course. The old valley just referred to extends south to the South fork, and north probably to the Stewart and is occupied in turn by a number of streams along different portions of its course.

The principal tributaries of the North fork are Barr, Husky Dog and Cache creeks from the north and Clearwater creek from the south. These streams all carry considerable volumes of water, and occupy deep, wide valleys. Cache creek, the only one examined, has a width of about 50 feet, and a length measured along the valley of 20 miles. The valley of this creek is wider than that of the main stream and extends through to the South fork of the Stewart. The summit is close to the Stewart valley and the drainage is all southward.

Topography

The North fork below Barr creek is bordered on the north by a long ridge and on the south by a high wooded plateau. Six miles above Barr creek the river bends suddenly northward, between two lofty mountain ranges, and for the remainder of its course traverses a continuously mountainous country. The name Selwyn range is proposed by the writer for this group of mountain ranges. The summit range of the Selwyn mountains forms the Yukon-Mackenzie watershed—and the whole group may be considered as one of the sub-ranges of the Rocky mountains. The central portion of the range is drained on the west by the North fork of the Macmillan and the South fork of the Stewart and on the east by Gravel river, all large, rapid streams. The north and south limits of the range have not yet been defined.

Selwyn range differs from the main range of the Rocky mountains further south in consisting of a number of irregular groups of mountains and not of a series of parallel longitudinal ridges. This feature is due largely to the presence in the range of several large granite masses, cutting the argillites and cherty rocks of which the mountains are mainly formed. The mountain groups are occasionally separated from each other by wide, low passes connecting the main drainage line. The mountains have a height of from 3,000 to 5,000 feet above the valley, or from 6,000 to 8,000 feet above the sea. Their general appearance is rather subdued, as the argillites and cherts when horizontal, or nearly so, weather into rounded elevations without marked individuality. The sculpturing in the granite areas is, however, bolder and more rugged, and the shattered pinnacled crests which often surmount the ridges of sharply tilted cherts and agglomerates, give variety to the view.

The South Fork

The South fork at its entrance to the main river is very unlike the North fork. It is rather wider, having a width of 250 feet; the current is slack for several miles above its mouth, the colour of the water is much darker and the temperature slightly higher than that of the North fork. The stream as far as examined has many of the characteristics of the main river. For the first twenty-five miles, following the windings of the stream, the average grade is about three feet to the mile; from this to the canyon the grade is probably five feet. The speed of the current varies from two to five miles an hour, with occasional accelerations. Fifty-eight miles from the Forks is a canyon about half a mile in length, the river breaking into three rapids on its course through it. Beyond the canyon the valley widens out, the grade increases and the river runs swiftly around sharp bends and resembles the North fork in character during the remainder of its course.

The general upward direction of the South fork is south-easterly, but toward the head it appears to bend to the north, and one of its upper branches heads quite close to those of the North fork. The first tributary stream enters the South fork from the south at a distance of twenty-four miles from the Forks; beyond this are several small streams coming in from both sides. The principal tributary is Riddell river entering from the south, forty-six miles from the Forks. This river is 125 feet wide, the water is of a brown colour, and the current is slack, moving at the rate of about two miles an hour at the lower portion; the grade increases slightly, higher up the stream, with occasional small riffles.

Twenty-six miles above its mouth Riddell river divides into two branches of about equal volume, the one from the south coming in with the velocity of a torrent. Beyond this the easterly branch is still water for about a mile, then becomes swift and the river from this part onward is impassable with canoes.

Topography

The valley of the South fork bears such close resemblance, both in grade and cross section, to the main river valley, that it may be regarded as a continuation of the latter.

For about ten miles by the valley above the Forks the South fork is bordered on the south by long ridges of fairly regular outline rising from 500 to 1,200 feet above the valley; these slope gently back from the river banks and are thickly covered with moss and small spruce. Beyond this the ridges become lower and recede from the river, the valley widening out on both sides. Sixteen miles, by the valley, from the Forks is a very pronounced depression to the north of the river. This depression runs through to the North fork, a distance of about eleven miles. The nature of the floor of this valley is concealed by a thick growth of small spruce and a deep covering of moss, but from the absence of rock exposures and the presence of numerous small lakes it is assumed to be an old valley of erosion, partially filled up by deposits of loose material of glacial origin. The floor of this valley rises to a height of 300 feet above the level of the South fork, and to about 170 feet above the North fork.

East of this valley and on both sides of the river are mountain groups, those to the north rise gradually by a series of ridges and culminate in several lofty peaks, which form an important spur of the Selwyn range. The group to the south is known as the South Fork mountain, and bears a rough resemblance to an elevated table land. The watershed of this group is close to the South fork and one of its chief features is the deep channels which the streams have cut in its flanks. Here are seen gorges V-shaped, with walls sometimes 500 feet in height.

Beyond the canyon the valley opens out again and widely isolated groups of high mountains are to be seen in the distance to the east and south, while the intervening country presents a succession of low parallel ridges with even outlines. Riddell river flows through this rolling country, slowly cutting down its bed in sand and gravel deposits.

Terraces, well preserved and continuous, are to be seen in this part of the valley; the highest well marked ones were found at an elevation of 600 feet above the river level, or 3,000 feet above the sea.

Forests

The principal tree found along the valley of the Macmillan is the white spruce (*Picea alba*). This tree is found both in the valley bottoms and on the mountain sides to a height of 2,800 feet above the valley at the mouth of the river and 1,800 feet above the valley at Cache creek. Groves of white spruce with trees measuring from one to two feet in diameter occur on most of the river flats and alluvial islands, and in a few localities individuals of this species were seen which measured three feet in diameter. The groves are small as a rule, but the aggregate amount of good spruce timber in the valley is considerable. Among the other trees noticed may be mentioned the black spruce (*Picea nigra*), the aspen (*Populus tremuloides*), the balsam poplar (*Populus balsamifera*), the black pine (*Pinus Murrayana*), the balsam fir (*Abies subalpina*), and a birch (probably *Betula papyrifera*). The black pine occurs in large groves on the benches along the lower part of the Macmillan valley and was traced eastward for thirty miles beyond the fork. It seldom exceeds nine inches in diameter. The balsam fir occurs mostly on the mountain slopes and was seldom seen on the river flats. It is found all the way to the tree line, but seems to thrive best at an elevation of 1,200 feet above the valley, the trees gradually decreasing in size above and below this elevation. The birch is usually small and not very abundant.

The forest along the main Macmillan and up both forks for some distance is fairly luxuriant and very similar to that on the Lewes and Upper Yukon. On the upper portion of the North fork the trees are much smaller and more scattered, and the prevalence of white reindeer moss on benches and mountain slopes contribute a sub-arctic character to the landscape.

Geological Section on the Macmillan and down Pelly River

The Macmillan valley does not afford a good geological section, as it is filled with glacial drift and bed-rock is seldom exposed. The frequent long gaps in the valley section, rendered necessary an examination of the bordering ridges and mountains, on all of which good exposures were found. Some time was spent on the Pelly below the mouth of the Macmillan, as only a hurried examination of the rocks was made by Dr. Dawson in 1887.

Steep mural cliffs of basalt occur along the right bank of the Pelly above its mouth and rounded hills of massive gray biotite granite on the left bank.

The basaltic plateau occupies the angle between the Pelly and the Yukon and extends down the latter river about twelve miles. It has a height of about 520 feet. A typical well-preserved volcanic cone built largely of vesicular basalt occurs a few miles north of the Pelly. The cone has a height of 2,570 feet above the river, and of about 1,000 feet above the general level of the country in its vicinity. The crater in the summit of the cone has a depth of 450 feet and a width at the bottom of 300 feet.

The last lava flow, now represented by a ridge of basalt fifty feet high, escaped through a break in the encircling wall of the crater and streamed to the eastward. The date of this volcanic cone is comparatively recent as its outlines have not been modified by denudation to any material extent. It is unlikely that all the basalts in the vicinity issued from this cone and it is probable that other vents will be discovered when the country is closely examined. The basalts are replaced four miles up the valley by grey biotite granite, and the latter, five miles further on, by crystalline schists.

The schists include several varieties, the principal one being a hard quartz-mica schist evidently an altered clastic, garnetiferous schists, chloritic and hornblendic schist, and bands of white crystalline limestone. These rocks are associated in places with granite-gneisses and evidently represent the Nasina series described in previous reports as occurring on the Yukon and Stewart rivers and in other localities. They have an east and west strike, and outcrop along the river in frequent exposures up to Willow creek, a distance of over twenty miles. East of Willow creek the Pelly winds through a wide depression filled with glacial deposits, and destitute of exposures of older rocks. The depression extends southward along Mica creek, the outlet of Tatlmain lake and may be underlain by the Cretaceous coal-bearing rocks which cross the Lewes at the Five Finger rapids. Drift lignite was found on Mica creek, and also on the Pelly below the mouth of this creek.

The hills which border the depression, just mentioned, on the north-east consist of sheared granite-gneisses similar to those along the Yukon valley, and evidently like them of eruptive origin. They are concealed along the river but outcrop in Knob Hill, north of Willow creek and Ptarmigan mountain, south of Granite canyon and also at one point above Gull rock in Granite canyon where they project up into the andesites.

The granite-gneisses are overlaid in the valley of the Pelly for some miles below Granite canyon by andesites, and these rocks form the high valley walls in the lower portion of the canyon. The andesite is associated in a couple of places with soft yellowish tuffaceous sandstones and dark carbonaceous shales. The latter at one point near Gull (Needle) Rock pass into an impure lignite. These carbonaceous beds are probably of the same age as the lignite-bearing beds at Five Finger rapid which hold Cretaceous fossils. (Later work has assigned these beds an early Tertiary age (*see* Mem. 189, p. 39).)

East of Gull (Needle) Rock, a name given to a sharp splinter of andesite forty feet in height in midchannel, the canyon walls consist largely of volcanic bombs. The upper part of the canyon is cut through coarse gray massive granite. Between the upper end of Granite canyon and the mouth of the Macmillan, the rocks exposed in the valley consist of chlorite and sericite schists, passing in one place, into an augen gneiss. These rocks resemble the Klondike schists which are known to be, in part at least, of eruptive origin.

Macmillan River Section

The Macmillan mountains north of the lower part of the Macmillan river consist largely of a quartz schist or felspathic quartzite, the precise character of which has not been determined. This rock is coarsely schistose, varies in colour from white to black and is jointed at right angles to the bedding planes. It is interbanded with dark argillites, mica schist and crystalline limestone.

A couple of rocky bluffs south of the river, one 1,000 feet in height, are built of white coarsely crystalline limestone containing numerous fragments of crinoid stems, probably indicating Carboniferous age. The limestones overlie chlorite and sericite schists, on which they probably rest unconformably. Several small areas of eruptive rocks, mostly granite and andesite, occur in the Macmillan mountains.

The Macmillan mountain beds have a general N.W. and S.E. strike and dip to the S.W.

They are succeeded and apparently underlain, ascending the river, by hard dark argillites, passing in places into quartzite bands and inclosing occasional beds of limestone. These rocks are well exposed in the southerly slopes of Kalzas mountain, and farther to the east in Lone mountain and the summit of Dromedary mountain. They are cut off at the summit of Kalzas mountain by granite, and are apparently underlain on the north-east by a band of breccias or agglomerates consisting mostly of angular fragments of dark and occasionally green and red cherts, imbedded in a siliceous matrix. The chert breccias form the eastern part of the Kalzas range and also outcrop in the lower slopes of Dromedary mountain south of the river.

The chert breccias are followed, apparently in descending order by slates, alternating in places with dark cherts, and then by a great series of tuffs, grits, quartzites, and red, green, gray and striped slates and schists. The red slates and associated rocks occur along the Macmillan from a point a few miles above the mouth of Moose river up to the Forks and beyond. They form the greater part of Plateau mountain north of the Macmillan and the Russell mountains east of Russell creek. A wide band of dark brittle cherts interbanded with the red slate series crosses Plateau mountain west of the summit, and massive amygdaloids, passing in places into a schist, outcrop north of the valley a few miles below the mouth of Russell creek.

The red slate series, like the beds in the lower part of the river, have general north-west and south-east strikes and south-west dips. The attitude of the beds apparently indicate a descending series from the mouth of the Macmillan to the Forks, but the regularity of the dip is probably due in large measure to faults and over-turn folds.

The rocks along the main Macmillan may be divided tentatively into two great groups. One group consists of argillites, quartz-schists, quartzites, and limestones and the other largely of volcanic fragmental rocks including tuffs, felspathic grits, and red, green, brown and striped schists. The latter group are interbanded with and are overlain by cherts and argillites, above which are chert-breccias.

North Fork Section

Striped and green schists belonging to the red slate series are exposed on the North fork for some miles above its mouth and are then replaced by dark argillites holding occasional beds of limestone. The argillites are less altered than the red schists and associated beds, and the cleavage planes are subordinate to the bedding planes. They are probably the equivalents of the argillites and cherts which overlie the red slate series on the main river above the mouth of Moose river. These argillites have a wide distribution as they are found all along the North fork up to the mouth of Cache creek and on the lower part of Cache creek. Above the mouth of Husky Dog creek they alternate with dark, brittle, flinty beds, which are referred to as cherts, and are largely due to an infiltration of the argillaceous beds by amorphous silica. These cherts occur both in thin beds, and in bands up to a thousand feet or more in thickness. They are the most prominent rocks in the Selwyn range.

The schists and quartzites of the red slate series were noticed at several points along the North fork, especially in the vicinity of the eruptive masses but no large areas were determined.

The argillites and associated cherts are replaced near the head of Cache creek by an alternating series of chert breccias, shales, and dark limestones at least 5,000 feet in thickness. The chert breccias resemble those in the Kalzas range north of the main Macmillan and are apparently a repetition of the same series. The angular chert fragments, the principal constituent of the breccia, are precisely similar to the chert beds and bands found lower down the river and are no doubt derived from them.

The North fork section may be summarized as consisting of three sets of beds, viz.: a lower series of red, green, and striped schists, with tuffs and quartzites, a middle series of argillites and cherts, and an upper series of chert-breccias and shales.

South Fork Section

The rocks on the South fork of the main Macmillan are similar to those on the North fork. The red and green schists occur near the mouth, but are soon replaced by argillites and cherts, and the latter twenty miles above the Forks are followed by chert breccias, shales, sandstones and limestones which continue as far as the mouth of Riddell river. Beyond this the rock is principally shale of a compact variety, which becomes hardened and altered near the intrusive masses. The mountains to the north of the river are composed of granite and those to the south of andesite. The latter rock cuts through the shale of the valley at a height of about 1,500 feet above the river.

About eleven miles above the mouth of Riddell river several dykes cut the shales. These dykes harden the latter, which here form the walls of a narrow canyon about half a mile long. The bedrock of Riddell river is a soft, crumbling, black shale with occasional harder beds. The age is uncertain as no fossils were found, but they are probably younger than the chert-breccias.

Granites and allied rocks and andesites occur at several points along the Macmillan and its tributaries, but as the specimens have not been examined microscopically, only a brief reference will be made to them here. A number of irregularly distributed granite areas occur in the Selwyn range, where they form the central portions of some of the principal mountain groups.

The granite is of the usual gray biotite variety, is often strongly jointed and weathers into conspicuous cliffs and bold rocky summits. Areas of granite also occur east of Russell creek, on the northern portion of Kalzas mountain, and crossing the Pelly river a few miles below the mouth of the Macmillan.

The South Fork mountains were found by Mr. Keele to be built largely of andesites, and small areas of this rock occur on the Macmillan mountains, and also at the Granite canyon on the Pelly. The andesites are much younger than the granites and at the Granite canyon are associated with lignite-bearing beds of probably Cretaceous age*.

General Glacial Features

During the glacial period a glacier descended the Macmillan river valley from the Selwyn mountains to its mouth and continued down the Pelly river to a point about 20 miles above Fort Selkirk. Glacial groovings and striæ occur at a number of places along the bottom of the valley, and on the lower slopes of the mountains bordering the valley up to a height of 1,200 feet. The direction of the ice flow was westerly and coincided very closely with that of the valley. The thickness of the ice, judging from the height at which foreign material was found, was 3,000 feet in the western portion of the Selwyn mountains, 3,300 feet at Dromedary mountain, and 2,000 feet at the Macmillan mountains. The upper surface of the glacier appears to have been nearly level from the Selwyn mountains to Dromedary mountain, the slope being less than that of the present valley, but west of this point the western declination averaged nearly 200 feet to the mile.

The ice even in the Selwyn mountains did not cover the higher peaks or, if it did, has left no trace of its presence, and while the valleys and depressions in the broken country to the west were deeply submerged all the principal elevations remained uncovered.

Foreign material in the Macmillan mountains is found up to a height of 2,000 feet. Below this elevation the slopes are comparatively smooth, but above it the harder bands of rock often project above the surface in crumbling walls and loose rocky points which show no evidence of ever having been disturbed except by the ordinary agents of sub-aerial denudation.

The deposits of the ice period, consisting of boulder clays, gravels, sands, silts, and clays, are exceedingly irregular in distribution and sequence

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* Now believed to be Tertiary.

and indicate rapidly changing conditions along the valley. Beds of gravel, evidently deposited by running water, fine silts which have slowly settled down in still water, and glacial boulder clays often alternate several times in the same section.

Boulder clay occurs in disconnected patches all along the Macmillan valley, and down the Pelly for some distance below the junction of the two streams. The heaviest and most continuous deposits of this material noticed occur on the Pelly river above Mica creek, near the western limit of the glaciated area. Sections at the cut banks along this portion of the river show a bed of typical boulder clay, filled with glaciated boulders, forty feet in thickness.

The upper surface of the boulder clay bed is level and is covered with rolled gravel alternating in places with sand. A layer of large boulders occasionally occurs at the bottom of the gravels.

Besides the main boulder clay bed at the base of the glacial deposits, several smaller beds alternating with silts, sands and gravels are exposed higher up in the face of a steep terrace which follows the river on the north. The section is concealed in places and a complete record could not be obtained. Granite boulders foreign to the locality occur on the hill sides at this point up to a height of 850 feet above the river.

The boulder clay is underlaid in some places by a bed of rolled gravels, but frequently rests directly on the bed-rock. It is overlaid as a rule by silts, sands and gravels, inclosing occasional beds of boulder clay. These deposits are exceedingly irregular and their sequence varies in every section examined. The thin silt beds are often folded around irregular patches of coarse gravel of from three to six feet in thickness and in places are sharply flexed and even overthrown.

The reason for this singular attitude of the silt beds is not clearly understood, as the movement which produced them, if it were movement, did not affect the associated coarse sands and gravels.

It is possible that the folding in some instances was caused by the pressure of ice descending the valley and dragging over the beds, but this explanation does not appear to be of general application. In some cases the appearance of the beds suggested the deposition of the silt beds in quiet water around masses of gravel brought down into the valley by torrential side streams. The peculiar folded character of the silt beds overlying the boulder clay in the Macmillan valley was also noticed in previous explorations on the Teslin, the Lewes and the Stewart.

The boulder clay in the lower part of the Macmillan valley is overlaid by an important clay bed at least 200 feet in thickness. The clay is bluish in colour, is indistinctly bedded and is very plastic, rendering it peculiarly liable to slides. The clay is very pure as a rule, but in places appears to pass upwards into a silt. It is overlaid by sands and gravels. The clay bed was traced from the mouth of the Macmillan up the valley for sixty miles, but is not found on the Pelly below the mouth of the Macmillan.

It was evidently deposited in a long narrow lake of considerable depth, probably held in by an ice dam at the mouth of the Macmillan.

The lower slopes of the mountains where it occurs are faintly terraced up to a height of at least 1,500 feet.

The alternating and irregular beds of silts, sands, gravel and boulder clay which form the upper part of the glacial deposits along the Macmillan valley evidence a period of rapid and complex changes, since quiet water, swiftly running streams and ice, are all necessary to explain them. The surface of the narrow valley-plain built up by these deposits is always more or less pitted, and in places is formed of a complicated series of interlacing ridges, some of them evidently of morainic origin inclosing pits and basins often fifty feet or more in depth. A section of one of those ridges showed it to consist mainly of coarsely stratified sands and gravels with some soft boulder clay.

The sand and gravel beds possessed a rough anticlinal attitude, corresponding in a general way with the outline of the ridge, but much flatter.

The thickness of the drift deposits along the Macmillan is variable but usually measures from 400 to 500 feet. Kalzas river, one of the main tributaries is lined with conspicuous terraces up to a height of 900 feet.

Lakes are common throughout the glaciated district. A number of small lakes occupying shallow rock basins occur in the granite ranges of the Selwyn mountains, and the pits and hollows inclosed by the morainic ridges are often partially filled with water.

The larger lakes like Moose lake and Kalzas lake occupy long depressions in the glacial plains, probably produced in some cases at least by the thawing out of masses of ice left behind on the retreat of the main glacier.

Another class of lakes common in all the valleys simply represents abandoned portions of old river channels.

Economic Geology

The Macmillan river has not so far produced any gold, although it has been more or less prospected along its whole course. Fine colours are present everywhere, but no pay bars, such as have been worked on the Stewart, Pelly and other tributaries of the Yukon, have been discovered. The old quartz-bearing schist and gneiss which contribute the gold to these streams are replaced in the valley of the Macmillan by younger formations, none of which have proved to be notably auriferous.

The most promising formations for minerals of economic value are the quartz schists and accompanying chlorite, and sericite schists near the mouth of the river and the wide band of red, green and dark schists and associated rocks which crosses the valley in a diagonal direction at the Forks and extends up and down the river for a considerable distance. Both these formations are cut by occasional quartz veins and silicified zones, but the few specimens collected proved on analysis to be barren. Argillites heavily impregnated with pyrite occur in Lone mountain and also in Dromedary mountain. Specimens were analysed but yielded nothing of value.

The only tributary of the Macmillan on which coarse gold has been definitely reported is Russell creek. This stream enters the Macmillan from the north, four miles below the Forks, and cuts through the red schist series referred to above along its whole course. A mining concession embracing the larger part of the main valley has been granted to a company, but no work was in progress during the past season and no definite information in regard to values was obtainable. Some prospecting was done above and below the concession during the season, the results of which were not considered favourable, although fine colours and an occasional coarse colour were obtained.

Russell creek occupies a wide heavily glaciated valley, floored, especially in the lower part, with heavy deposits of silts, sands and gravels mostly of glacial origin. This drift material thins out gradually ascending the valley, and near the summit the bare rocky floor of the old valley bottom is often uncovered. The present stream occupies a narrow depression sunk through the drift deposits down into the bed-rock beneath. The grade of the stream is heavy, averaging 100 feet to the mile, the flow of water in the main stream and also in some of the steep tributaries is ample for hydraulicking at all seasons and the conditions are generally favourable for cheap working. The prospecting done up to the present time has proved the presence of coarse gold in the creek, but has done little more. The extent of the auriferous gravels and their average value still remains to be determined.

A small seam of carbonaceous shale or impure lignite, of no value, occurs at Granite canyon on the Pelly, and drift lignite, as stated on a previous page, was found on Mica creek. It is highly probable that lignite-bearing beds underlie the comparatively low country along Mica creek, but, as no surface exposures were seen, definite information on this point can only be obtained by boring.

A shaft sunk on an easterly branch of Mica creek, about eight miles from the Pelly, is reported to have passed through several small seams of lignite.

1903

Introductory Note

The following note*, by Dr. Robert Bell, Director of the Geological Survey of Canada, refers to Yukon field work in 1903:

"In the Yukon district, Mr. R. G. McConnell, without a professional assistant, completed the work which was intended to be done for the present in the Klondike gold mining area. This consisted in tracing out the boundaries of the different rock-formations on the ground and laying them down upon a contoured topographical map which he had prepared in previous years, by the aid of Mr. Frank Johnson and Mr. Joseph Keele. Mr. McConnell, while performing his geological work in this district, also kept in view the desirability of establishing a water-supply for common use in placer mining in the future, and he has prepared an elaborate statement on the subject for the information of the commissioners who were appointed by the government last summer to investigate this matter. The maintenance of a large production of gold in this district in years to come depends principally on obtaining a better supply of water than is procurable at present. Mr. McConnell's investigations afford further evidence of the local origin of the gold of the Klondike area."

Introductory Note

by R. G. McConnell

"The principal work of the season consisted of a somewhat detailed examination of the geology and mining resources of the Klondike region; but before proceeding there, a short trip was made to Frank, Alberta, with Mr. Brock, for the purpose of examining into the causes of the disastrous landslide which occurred at that place in April. A short report on the slide, with maps and illustrations, was prepared before leaving for the field.

"I left Ottawa for Dawson on June 12, and arrived there on June the 24th. The three months of open season remaining was spent altogether in the Klondike gold fields, with the exception of a few days occupied in a trip to the coal-field recently opened up on Coal creek, and in a hurried examination of the Ogilvie range, at the head of Rock creek.

"A preliminary examination of the Klondike gold fields was made by the writer in 1899, and a report of it published the following winter. It is intended to re-write this report during the coming winter and to add to it the additional information acquired since. It is unnecessary therefore in this summary to give any detailed description of the district or do more than refer to some of the changed conditions."

The summary report that followed has been omitted from this volume in so far as it dealt with the Klondike district, as this information is contained in the subsequent full account of the 'Klondike Gold Fields'. Those parts of the summary that follow are Mr. McConnell's account of prospecting the Ogilvie Range and of lignite areas in the vicinity of the Klondike.

PROSPECTING IN THE OGILVIE RANGE

Considerable prospecting was done during the season in the Ogilvie range, north-east of Dawson, and a number of claims were located on Rock

*Sum. Rept., 1903, pt. A, pp. 3-4, Ann. Rept., vol. XV (1906).

creek, a tributary of the Klondike, and on Spotted Fawn creek, a tributary of Twelve-mile river, but only a few of these were examined. The rocks on the south-westerly slope of this range consist of cherts, dark slates, shales and quartzites, with occasional bands of tuffs and green schists, a succession very similar to that on the upper Macmillan river. Areas of igneous rocks also occur, principally syenites and diorites, and on the North Fork of Spotted Fawn creek exposures of an interesting leucite rock were found.

A marked feature of the range is the peculiar forms of the mountains in an area of syenite porphyry, which extends from Spotted Fawn creek northward across Twelve-mile river. This rock is strongly jointed vertically and weathers into ruinous, wedge-shaped ridges, surmounted by lines of sharp pinnacles and lofty tower-shaped peaks. The pillared character of the region is so remarkable that the prospectors have given it the name of the tombstone country.

A number of claims have been staked in this syenite area, principally in small, irregularly shaped inclusions of altered slate. No veins were seen. The inclusions contain varying quantities of pyrite and weather to a rusty colour on the surface. They are reported to carry gold. A small vein, a few inches in width, carrying galena and pyrite, occurs on the North Fork of Spotted Fawn creek, in a porphyry dyke cutting slates and quartzites. The vein is too small to be of value. None of the prospects examined appeared promising, but they show that the region is metalliferous to some extent and may therefore contain deposits of value.

Lignite Areas

Various efforts have been made since the Klondike gold fields were discovered to utilize the lignite seams in the vicinity. A long, narrow area of lignite-bearing rocks, probably of Tertiary age, occurs along the base of the Ogilvie range, and has been traced from the Klondike river, in a north-westerly direction, to a point beyond Cliff creek, a distance of over 60 miles. The streams draining this portion of the Ogilvie range cross the lignite area on their way to the Yukon, and on most of them outcrops of lignite coal are found. Some mining has been done on Rock creek and on Cliff creek, a small stream entering the Yukon from the east a few miles below Forty-mile river, but work is now stopped at both places.

During the past season considerable work has been done at Coal creek by the Coal Creek Coal Mining Company. The seam worked occurs on the South Fork of Coal creek at an elevation of 960 feet above the Yukon, and the workings are connected with the Yukon by a narrow-gauge railway, eleven miles and three-quarters in length.

The seam worked, varies in thickness from 4 to 11 feet, and is overlaid by 3 inches of clay, followed by 12 feet of moderately hard sandstone. The floor consists of 6 feet of clay, resting on 16 feet of sandstone, below which is a band of black shale. The seam dips to the south-east at an angle of 45 degrees for a distance of 210 feet from the surface, and then bends round and dips to the south-west. The principal working consists of an incline 490 feet in length. The lignite is hauled to the Yukon over a narrow-gauge railway just completed, and taken up the river to Dawson, a distance of about 50 miles on barges. Bunkers of 500 tons capacity are in course of construction at the mine and at the river.

The coal from this seam is of good quality, and is very similar to the

Cliff creek coal, an analysis of which is published in the 1901 Summary Report. It is pure for a lignite, and has been used with satisfactory results, both for steam and heating purposes. It is sold at Dawson at $16 per ton. The price of spruce wood—the usual fuel—is generally $7 to $8 per cord at Dawson, and $8 to $15 on the creeks.

A second lignite area occurs south of the Klondike on Indian river. A small seam outcropping on Ruby creek, a tributary of Indian river, was worked to some extent during the winter of 1902, but has since been abandoned. At the time of my visit the tunnel had fallen in, and nothing could be learned in regard to either the character or size of the seam.

REPORT ON THE KLONDIKE GOLD FIELDS

by R. G. McConnell

Historical Notes

An account of the early gold discoveries in the Upper Yukon is given by Dr. Dawson in the Report of the Geological Survey for 1887-88, pages 178-183 B and also by Mr. Goodrich in the Eighteenth Annual Report of the United States Geological Survey, 1896-97, part III, pages 103-124 and need not be repeated here at length. Briefly, the existence of gold on the Yukon has been known since 1869, at least. The first prospector entered the country, according to Dawson, in 1878, and to Goodrich, in 1873. Bar-mining commenced on the Big Salmon in 1881 and discoveries of productive bars on the Lewes, Pelly and Stewart soon followed. The latter stream proved the more productive and in 1885-86 was actively worked. The first discovery of coarse gold was announced in 1886. The discovery was made on Forty-mile river and the greater part of the new field proved to be in Alaskan Territory. Further discoveries extended the producing area to streams flowing into Sixty-mile river in Canadian Territory. The Sixty-mile river streams continued to be the chief producers, until the announcement in 1896 of the discovery of astonishingly rich creeks in the Klondike district drew most of the miners away.

Although the Klondike district did not become prominent until 1896, it was really discovered two years earlier. In 1894 some miners working on the bars on Indian river did some prospecting on Quartz creek and in the following year some gold was taken out. Reports differ as to who made the first discovery on Quartz creek, several persons claiming the honour. In the winter of 1895, Bob Henderson crossed the ridge separating Quartz from Hunker creek and found gold on Goldbottom creek, a tributary of the latter. He did some work on this creek in 1896, and it was while returning from a visit to him that Carmack made his famous discovery on Bonanza creek, which led to the rapid over-running of the whole district. In 1897-98 a stream of adventurers, including people of all trades and callings, from all parts of the world, poured into the country, all heading for the Klondike. The population of the camp rose to about 30,000 and the production increased rapidly, reaching a maximum in 1900, when it exceeded twenty-two millions of dollars.

The discovery of the Klondike gold fields completely changed conditions in the hitherto unorganized and almost unknown Yukon Territory. The town of Dawson was built at the confluence of the Yukon and Klondike rivers and sprang rapidly into importance, soon superseding Fortymile as the chief commercial centre. A local administration, with courts of Justice and other organizations necessary to government, were quickly established. The demand for better transportation was met by the construction of the White Pass railroad from tide-water at the head of Lynn canal to the foot of the White Horse rapids on the Lewes river, from which point communication with Dawson is maintained by a large fleet of well-equipped river steamers. At the present time the trip from Vancouver to Dawson can be made in comfort in less than a week. Other notable improvements in the condition of the camp consist in the establishment of telegraphic communication with the outside world and in the construction by the Government of a system of roads from Dawson up all the producing creeks. These roads have proved a great boon to the camp, as the excessive rates of early days, now that freight can be moved on wheels, have been reduced to reasonable figures, and comparatively low-grade gravels on the distant creeks can be worked at a profit.

Extent and Situation of the Klondike Gold Fields

The Klondike gold fields are situated east of the Yukon river in latitude 60° north. They are bounded in a general way by the Yukon river on the west, by the Klondike river on the north, by Flat creek, a tributary of the Klondike, and Dominion creek, a tributary of Indian river, on the east, and by Indian river on the south. The area included between these boundaries measures about 800 square miles. The streams flowing through the area described are all gold-bearing to some extent, but only a limited number have proved remunerative. The most productive streams are Bonanza creek, with its famous tributary Eldorado creek, Bear creek and Hunker creek flowing into the Klondike, and Quartz creek and Dominion creek with Gold-run and Sulphur creek, two tributaries of the latter, flowing into Indian river. Besides these, claims have been worked at a profit on Allgold creek, a tributary of Flat creek, and on Eureka, a tributary of Indian river from the south.

Topography

General Surface Features

The Klondike region is a typical example of the thoroughly dissected upland. It forms part of the Yukon plateau and old peneplain, elevated at one period in its history into a high plateau and subsequently deeply trenched by a multitude of small streams, tributary to the main water courses. In comparatively recent times, a second elevatory movement has taken place, resulting in a further deepening of the valleys of from 500 feet to 700 feet. Portions of the old valley-bottoms, still covered with heavy accumulations of gravel, occur at many points, forming terraces of varying width, bordering the newer valleys.

Viewed from a distance, the Klondike district has a hilly, even montainous aspect, but in reality consists of a series of long branching ridges, the summits of which have been curved irregularly into hill and hollow by unequal denudation. Most of the ridges originate at or near the Dome, the topographic centre of the district, and the highest eminence in it.

The Dome is situated nineteen miles south-east of Dawson, about midway between Indian river and the Klondike. It has a height of about

4,250 feet above the sea, 3,050 feet above the Yukon at Dawson and about 500 feet above the ridges at the base. It is not conspicuously higher than the other hills in the neighbourhood, and the gradual decrease in height outwards along the ridges radiating from it, is scarcely noticeable to the eye. The Dome is the principal drainage centre of the district. From it, Allgold and Dominion creeks flow eastward, Quartz and Sulphur creeks southward, and Goldbottom and Hunker creeks northward. The ridges separating these streams, although deeply and repeatedly gashed by tributary valleys, are unbroken, and it is possible, starting from the Dome, to reach any part of the district without descending into the valleys. Subordinate drainage centres occur between the sources of Ensley and Nine-mile creek, of Baker and Boulder creeks, and at other places.

The ridges have an average elevation above the valley-bottoms of 1,500 feet and above the sea of 3,200 feet. They are round-backed, branching elevations with slopes of from 10° to 20°. The crest line usually follows a zigzag course along the heads of tributary valleys and is broken, at intervals, by rounded prominences and bare rocky points.

The valleys are flat and wide in their lower reaches, but gradually narrow towards their heads into steep-sided narrow gulches, which terminate abruptly in steep, rounded, cirque-like depressions cut into the sides of the ridges. The valley-flats are marshy, partly wooded, and wider on the Indian river than on the Klondike slope. The flats bordering the lower parts of Dominion creek have a width in places of nearly half a mile.

The lower slopes of the valleys are often conspicuously terraced. Well-marked rock-cut benches, usually supporting beds of gravel, occur along the Yukon and Klondike rivers and extend for varying distances up most of the creeks. The principal rock bench has an elevation near Dawson of about 300 feet above the Yukon or 1,500 feet above the sea, while smaller terraces and rolled gravels, occur up to a height of 700 feet above the valley-bottoms. The main terrace decreases in height ascending the Yukon and disappears near the mouth of the Stewart. It increases in height down stream as far as the mouth of Forty-mile river, where it has an elevation of about 700 feet above the valley-bottom.

The Klondike district has not been overridden by ice and the surface rocks, as is usual in unglaciated regions, are deeply weathered. A thick covering of decomposed schist, usually intermingled with slide rock, mantles the side hills nearly everywhere. On the ridges the covering is less, and the schists, often worn into fantastic shapes, occasionally project above the surface, or outcrop along the sides of the steeper hills.

Another feature which, although not especially connected with the topography, may be referred to here, is the permanently frozen condition of the surface. The thickness of the frozen stratum varies considerably, and is less on the ridges than in the valleys, and on southern than on northern exposures. A shaft sunk on the ridge south of Eldorado creek reached unfrozen ground at a depth of 60 feet, while one in the valley of Eldorado creek was stopped by running water at a depth of a little over 200 feet. Another shaft sunk through gravel, on the plateau between Bonanza creek and the Klondike river, passed through the frost line at a depth of 175 feet.

The summer heat has little effect on the frozen layer except in the few places where the surface is unprotected by moss. Exposed gravel beds in favourable positions thaw out to a depth of from six to ten feet, but where moss is present, frost is always encountered close to the surface.

Rivers and Streams

The drainage of the region empties into the Yukon. This great stream flows past the district with a width of over four hundred yards. It divides around numerous low-wooded islands and shifting bars, and runs with a steady current of about five miles an hour. Its valley is comparatively narrow, with few flats, and the river, sweeping from bank to bank in easy curves, washes alternately the bases of the hills on either side.

The Klondike and Indian rivers, which border the district on the north and south respectively, are comparatively small streams. Indian river, formed by the junction of the Dominion and Australia streams, has a width of from twenty to thirty yards but is quite shallow, the water on the bars at summer line seldom exceeding a few inches in depth. The channel is filled, for a long distance below Quartz creek, with large angular blocks of schist, and the navigation of the stream, even with small boats, is difficult. The grade of the valley averages about eighteen feet to the mile. The Klondike is a much larger stream, having a width of from 30 to 50 yards. It is interrupted by frequent bars and has a fall of from 12 to 15 feet to the mile. The average flow at mean level is about 120,000 cubic feet per minute. Both streams are inclosed in wide flat-bottomed valleys.

The streams draining the interior of the district are small, seldom exceeding fifteen feet in width, even near their mouths, and are very similar in general character. They rise in a multitude of small branches high up on the sides of the ridges and descend rapidly for the first few miles. Farther down, the inclination gradually diminishes and in the lower reaches is usually very small. The grade of Dominion and other Indian river streams does not exceed twenty-five feet to the mile, near their mouths. The Klondike streams are somewhat steeper, falling about forty feet to the mile.

The cutting down of the forest which covered the hillsides before mining operations began, and the burning away of a portion of the moss has had considerable effect on the drainage. The snow, as a consequence of this, melts more rapidly and spring floods result, while, later in the season, the supply of water is often insufficient for sluicing purposes. Schemes to impound the spring flood in the upper unproductive portions of the valleys have been proposed, but nothing has been done so far in this direction.

Forest

The forest trees consist of white and black spruces, the aspen and balsam poplars and a species of birch. No pine or fir trees were noticed. The lower ridges and the slopes of the higher ones up to a height of 3,500 feet above the sea are generally wooded, and stunted spruces occur sparingly on the highest points in the district. The flat valleys are only partly wooded. Groves of spruce and poplar occur at intervals, but alternate with bare swamps and marshes too soft to support a forest growth.

The white spruce is the most important tree for general purposes in the district. It is usually small on the ridges, seldom exceeding a foot in diameter, but in the valley-flats occasional specimens attain a diameter of over two feet, and a large proportion of the logs cut for lumber measure from nine to fifteen inches across. The supply for the mills at Dawson is mostly obtained from the flats and islands along the Upper Yukon and from the Klondike valley, and is ample for all purposes for many years to come. The Klondike is bordered at intervals all the way from its mouth to the mountains by groves and small tracts of spruce forest of surprising size and quality, considering the latitude, and supplies of well-grown spruce timber are also available from all the large tributaries of the Upper Yukon, as well as from the main valley, and can be easily and cheaply floated down to Dawson.

Geology*

General Statement

The Klondike district and adjoining region is underlaid by a complex of rock formations ranging in age through the greater part of the geological scale and presenting extreme variety in structure and composition. The region has been repeatedly broken through by igneous intrusions at widely separated periods, and has been subjected to enormous pressure from earth movements. Alterations in the character of the rocks induced by dynamic and associated metamorphic agencies have proceeded to an extreme degree. Massive igneous rocks have been sheared, granulated and crushed into finely foliated schists, and the clastics in many cases recrystallized into the semblance of igneous rocks.

The oldest and most important formations in the Klondike district consist of ancient schists, partly of clastic and partly of igneous origin.

The southern part of the district is underlaid by altered sedimentary rocks now represented largely by grayish and dark quartz mica-schists and crystalline limestones. These are bordered on the north by a wide band of light-coloured, in places almost white, sericite schists alternating occasionally with greenish chloritic schists. These schists have been derived from igneous, and largely from massive igneous rocks. All the principal producing creeks occur in the area occupied by them. The sericite schists and associated rocks are replaced near the mouth of the Klondike river by green diabase rocks usually schistose but in places almost massive. They are everywhere greatly altered and, in Moosehide mountain, pass into serpentines. East of the diabase and serpentines area of Moosehide mountain the sericite schists alternate on the north with bands of dark quartz mica-schists, very similar to those bordering them on the south.

The old schist floor of the district is penetrated at numerous points by intrusives belonging to several groups. A massive coarse-grained grayish granite, resembling the coast granites, cuts the sedimentary schists on the Yukon river below Indian river. Serpentines, derived in part, at least, from peridotites, occur at several points on the crest of the ridge separating Hunker creek from the Klondike, and numerous small, usually oblong, areas of comparatively recent quartz porphyrites, rhyolites and andesites are dotted irregularly throughout the district. Massive diabases occur on Indian river below New Zealand creek, and in dikes in the Yukon valley opposite Indian river and on Eldorado creek. Unaltered sedimentary rocks, consisting of clays, shales, sands, sandstones, tuffs and conglomerates nearly destitute of determinable fossils, but probably Tertiary in age, overlie the schists in the lower part of the valley of Last Chance creek, and in separated depressions at several points around the outskirts of the district. They occur on the Klondike above Rock creek, on Indian river opposite the mouth of Quartz creek, and the apex of a wide area crosses the Yukon

* I am indebted to Dr. A. E. Barlow for detailed petrographical descriptions of the large suite of specimens collected as representative of the various rock types and formations noticed in the present report. This work has been fully quoted throughout that portion of this report relating to the geology and lithology.

valley below the mouth of Indian river. These recent sedimentary rocks are associated in every area with dikes, stocks, and sheets of andesite and, occasionally, with dikes and small areas of diabase.

The rocks of the district have been separated for purposes of description into the following groups:

Schists

Nasina series, Klondike series, Moosehide diabase.

Unaltered sedimentary rocks

Early Tertiary (Renai?), Late Tertiary (Flat creek beds).

Massive igneous rocks

Granite, diabase, andesites, quartz porphyries, serpentine.

Nasina Series

Under this head are included the old altered sedimentary rocks of the district. These rocks have been described under various names. They were first studied by Mr. J. E. Spurr of the United States Geological Survey in the Forty-mile district north-west of Dawson in 1897. Mr. Spurr, in his excellent and detailed description of the formation, separated it into two divisions, the lower of which he called the Birch Creek series, and the upper the Forty-mile series.

The prevalence of marbles in the upper series is given as the principal reason for the division. In other parts of the Territory where the formation has since been studied this distinction fails and it has been found impossible to apply Spurr's two names with any accuracy. In 1898 Mr. Brooks described what are evidently the same rocks on White river under the name of the Nasina series, and in 1899 the writer named them, from their occurrence on Indian river, the Indian River series. Subsequently, the Indian River rocks were traced into the Forty-mile district and found to be an easterly extension of the clastic series described by Spurr, but whether of the upper or lower division could not be determined. The name Kotlo series was proposed by Brooks in 1899 as a general designation for all the old altered clastics of the Yukon Territory and Alaska. A term of this kind, embracing a number of similar formations, is useful in the early study of a district but must eventually be superseded by more specific names. The name Nasina series has priority over Indian River series and has been adopted by the writer in preference to the two older names proposed by Spurr, as the minerological distinction on which these are based is apparently not persistent.

General Character

The Nasina series consists essentially of ancient siliceous and argillaceous sediments now altered into quartzites and quartz mica-schists. These are associated in places with bands of green chlorite and actinolite schists beds and bands of crystalline limestone. The green schists represent, in most cases, basic irruptive rocks, principally diabases and diorites intruded along the bedding planes of the older formation, and subsequently sheared and altered. The limestone beds formed part of the original deposit.

While the rocks of this series are everywhere altered there is a marked difference in the degree of alteration. In the least altered portions the constituents have a parallel arrangement, and micas and other minerals have been developed, but the original quartz grains are practically unchanged. In the most altered portions, the rocks have been completely recrystallized into fine-grained gneisses difficult to distinguish from certain phases of the sheared granitic rocks of the district. The principal field evidence of their clastic origin is afforded by their rapid alternation with quartzites and limestones and their gradual passage in places into the former. With the microscope, different stages in the recrystallization process can be detected. The clastic gneisses in some of the sections underlie the less altered quartz mica-schists and may therefore be much older, but as no unconformity or abrupt change in character was observed, they have been grouped together for the present.

Distribution

The rocks assigned to the Nasina series outcrop at intervals along the Yukon valley from a point a few miles below Selkirk down to Forty-mile river, and are also found on various tributaries of the Yukon, entering it both from the east and west. They occur in bands, from a few feet to several miles in width, separated, as a rule, by areas of granite gneiss* (Pelly gneiss). They are cut irregularly by the latter. The sections are, on this account, fragmentary and neither the top or bottom of the formation has so far been satisfactorily defined. In the Klondike district, the rocks of the Nasina series are exposed along the Yukon river from a point two miles below Ensley creek up to Indian river, and for some distance beyond. They were traced from the Yukon in a south-easterly direction up Indian river to Ruby creek where they disappear beneath Tertiary sandstone and conglomerates. They come to the surface again west of Eureka creek, and continue to the boundary of the district. On the Yukon, the continuity of the section is interrupted by a granite area and also by an andesite flow of moderate width. Besides the main occurrence of Nasina schists along the southern edge of the district, numerous small irregular patches of precisely similar rocks, often only a few feet in width, occur with the sericite schists of the Klondike series. One of these, on Dominion creek, has been mapped approximately but most of them are too small to show on the scale adopted.

An irregular area of dark and gray quartz mica-schists interbanded with green chloritic schists, occurs on the lower part of the Klondike river bordering the Klondike series on the north. In a preliminary report on the district, published in 1900, these were separated as the Hunker series, but in the present report they are included with the Nasina series, as the lithological characters have proved to be very similar.

Structure

The Nasina series include, so far as known, the oldest rocks in the Yukon Territory. They have a wide distribution but the various areas are comparatively small and differ greatly in degree of deformation they have undergone in the course of their long history. In the least disturbed areas the alternating shales, flags, quartzites and limestones, which represent the

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* Granite gneisses are extensively distributed in numerous areas along the Yukon valley and adjacent regions from the mouth of the Pelly river down to Fortymile river. The name 'Pelly gneisses' has been proposed for them by Brooks. They are described by Spurr under the name of the Basal granites, in the Eighteenth Annual Report of the United States Geological Survey, Part III, pp. 134-137; by Brooks in the Twentieth Annual Report of the United States Geological Survey, Part VII, pp. 460-463; and by the writer in the *American Geologist*, Vol. XXX, July, 1902.

series, are bent in easy folds with dips seldom exceeding 30°. In the more disturbed areas the dips are high, and sharp flexures, often passing into faults, are frequent. In some of the sections the argillaceous members of the series are distinctly cleaved, but the principal divisional planes everywhere correspond with, or are parallel to, the original lines of bedding.

The principal area in the Klondike occurs along Indian river and is cut transversely by the valley of the Yukon. The beds have a general synclinal attitude, both limbs of the syncline dipping towards a granite mass situated above Ensley creek. The beds in the southern limb dip regularly northward at angles of from 30° to 50°. The lowest beds brought to the surface by the syncline occur north of Reindeer creek. They are interbanded with granite gneiss and are themselves altered locally into fine-grained dark mica gneisses. The northern limb of the syncline is less regular than the southern one. The dips are high, often exceeding 60°, and the beds in many places are sharply plicated. The strongest crumpling occurs half a mile south of the northern edge of the formation. The strata here, for a width of several hundred yards, are bent, twisted and corrugated in an exceedingly complicated manner, while the beds above and below are comparatively regular. Besides the crumpling of the rocks in the northern limb of the syncline, they are also cut by numerous faults produced at different periods and often intersecting each other. The faults are small, as a rule, and in no place was any great displacement of the rocks observed. The throw is usually normal, but in some cases appeared to be reversed.

Notwithstanding the more disturbed and broken condition of the rocks in the northern limb of the syncline, they are less altered than the beds occupying a corresponding position in the southern limb. This is doubtless due to the absence of the intrusive sheets of granite gneiss associated with the latter.

The Nasina schists along the Klondike river are only shown in occasional exposures and no details in regard to their structure were obtained. The small areas inclosed in the igneous schists of the Klondike series conform in dip and strike very closely to the latter.

The rocks of the Nasina series represent altered argillaceous and siliceous sediments, the different varieties depending on the varying proportions of these originally present. The more siliceous sediments have hardened into micaceous quartzites and these pass gradually into gray quartz mica-schists, and, by a further decrease in the amount of silica present, into dark, glossy mica-schists. The minerals present are very similar in all the varieties but vary in importance. Quartz is the most abundant constituent. In thin sections it appears as a mosaic of small angular and sub-angular grains pressed closely together and arranged in narrow bands and areas separated by lines of sericite and biotite. The grains are occasionally drawn out in the direction of the schistosity. The quartz is usually associated with a subordinate quantity of feldspar. Biotite is conspicuous in most of the sections. The leaves are small and are usually arranged parallel to the planes of schistosity. Sericite is abundant, and chlorite calcite, kaolin, magnetite and pyrite are occasionally present, and more rarely garnet and tourmaline. The dark colouration is due largely to carbonaceous material disseminated in fine particles through the rock.

The beds and bands of crystallized limestone associated with the siliceous and argillaceous schists are usually more or less siliceous and, in places tremolite, sericite and other secondary minerals are developed in them.

Green chloritic and actinolitic schists form an important part of the Nasina series on the Stewart river and other places, but are not prominent in the main area of these rocks in the Klondike district. A band of green schists, consisting mostly of chlorite and epidote with some unstriated feldspar, probably albite, occurs in the Klondike valley opposite the mouth of Hunker creek.

Klondike Series

General Remarks

The Klondike series are the principal gold-bearing rocks of the Klondike district. They consist mainly of light-coloured sericite schists associated with a subordinate quantity of greenish chloritic schists. The two varieties often occur in alternating white and green bands easily distinguished in the field, but in most cases both sericite and chlorite are present in variable quantities, and the predominance of one or the other gives character to the rock.

The schists of these series differ from the Nasina schists in being mainly, if not altogether, of igneous origin. The original rocks varied widely in character, as both acid and basic surface and deep-seated varieties were present, and possibly tuffs as well. The principal types recognized consist of quartz porphyries, granite porphyries and basic porphyritic rocks. The former are now represented by sericite schists and ordinary and augen gneisses, and the latter by chlorite and occasionally amphibolite schists. All the varieties have a common schistosity which is also conformable, as a rule, to that of the bordering clastic schists.

The relative ages of the bands of sericite and chlorite schists could not be determined. The latter, in some instances, suggest dikes, but both sets are sheared alike and have yielded in equal measure to the dynamic and other metamorphic agencies which have affected the region. The granite gneiss probably represents the same magma as the quartz porphyry, cooled at a greater depth.

The Klondike schists often inclose small irregular areas and short bands of dark clastic schists identical in character with the rocks of the older Nasina series and probably representing undissolved portions of this formation. They are also pierced at various points by small stock-like areas or short oblong dikes of quartz porphyry, rhyolite and andesite. These rocks are much younger than the schists. They have not been crushed and have suffered little alteration of any kind.

Distribution and Correlation

The Klondike schists cross the central portion of the Klondike district in a band varying in width from ten to twenty miles and striking in a N.W. and S.E. direction. The extension of the band beyond the limits of the Klondike district has not been traced out. The formation is bordered on both sides by the dark schists of the Nasina series. The southern contact follows a nearly straight line. The northern boundary is more intricate, as it often bends sharply around angular bays of the dark schist and, in places, the two series of schists occur for some distance in alternating bands.

Sericite schists, identical in character with the Klondike schists, occur at various points in the Yukon territory, notably in the Forty-mile district, on Henderson creek, and in the Stewart valley. They are closely associated everywhere with the Pelly gneisses and in some instances, at least, simply represent an extreme schistose phase of these rocks. On Henderson creek, the schists and gneisses occur in alternating bands manifestly identical in age and origin, and in the Forty-mile district the gneisses are followed crossing the strike by sericite schists agreeing with them in dip and strike. The exposures here are imperfect and the exact contact was not seen.

In the Klondike district the sericite schists of the Klondike series in their extension eastward pass into or are replaced by granite gneisses, and gneisses also occur on Indian river along the southern border of the area. At the latter point, the gneisses pass gradually, going northward, across the strike into finely foliated schists.

A portion of the Klondike schists, a least, can therefore be referred with tolerable certainty to the age of the Pelly gneisses, and it is probable that the whole series belongs to the same period.

The rocks of the Klondike series are everywhere foliated, but have suffered unequally in this respect. In the less schistose varieties, the rock is hard, imperfectly cleavable, and weathers into angular striped blocks, or flags of moderate thickness. The more schistose varieties are soft and cleave easily in the direction of the schistosity into thin leaves or plates often an inch or more in thickness. Crinkled surfaces occur in both the hard and soft varieties, but are exceptional, and sharp plications are also rare, although present, at a few points. The planes of schistosity are not influenced in direction by differences in the character of the rocks, but traverse all kinds indifferently, and often pass from the sericite to the chlorite schists at angles to the plane of contact between them.

The strike is generally N.W. and S.E.—that is, parallel to the longest axis of the area, but to this rule there are many exceptions. On Bonanza creek the schists follow a serpentine course, and in the Yukon valley, near Baker creek, and on the ridge between Carmacks fork and Upper Bonanza creek, they strike almost at right angles to the general direction. The schistosity is peripheral in character, and the changes in the direction of the strike are commonly due to corresponding changes in the direction of the outline of the area. A secondary cleavage, cutting the main schistosity almost at right angles, was noted at a few points at Bonanza creek, but is not general.

Small folds in the schists occur at a few points, but over the greater part of the area the dip is persistently S.W. The low angle of the dip, in many places, is remarkable in the case of such a highly altered series of rocks. On Dominion ridge, the Dome ridge, and other places, dips of less than fifteen degrees are common, and high dips are exceptional throughout the whole area.

The Klondike schists, like the Nasina schists, are cut repeatedly in places by small faults, the observed displacements ranging from a few inches to a few feet in extent. A quartz vein, uncovered for sixty feet, in the Violet group of claims south of Eldorado creek, is broken by several faults with small throws, and at one point bends suddenly and follows for a short distance an old cross-fracture plane. The faultings here evidently belong to two periods, one younger than the quartz vein, and the other older or contemporaneous with it. The faults are seldom conspicuous, or even noticeable, except in the few places where the beds have been bared by mining operations, on account of the depth of the general surface decomposition of the rocks.

Sericite Schists

The principal rock in the Klondike series consists of a white or light green sericite schist originating largely from the deformation and alteration of quartz porphyries or allied rocks. The porphyritic character of the rock in places is still evident in hand specimens, and in the crushed varieties is usually easily recognizable in thin sections. The principal minerals of the sericite schist are sericite, chlorite, quartz, orthoclase and plagioclase. Biotite is conspicuously absent in most of the sections. Sericite is the most abundant micaceous mineral. It is usually associated with chlorite and this mineral is often present in sufficient quantities to give character to the rock. The quartz in the less altered varieties occurs in bluish blebs of moderate size wrapped round by small scales of sericite and chlorite, arranged in parallel leaves. In some of the specimens the quartz blebs are still unbroken; in others more or less granulation has occurred, resulting in the production of short tails. The quartz grains are occasionally accompanied by angular crystals of feldspar, and in a few sections feldspar is the only porphyritic mineral recognizable macroscopically. The feldspar is usually in an advanced state of decomposition and difficult to determine specifically. Both orthoclase and plagioclase are present, the former predominating.

The schists characterized by uncrushed quartz and feldspar phenocrysts are exceptional and occur mostly in the western part of the district. They have an irregular distribution and grade through varieties in which the porphyritic character can still be detected in thin sections, into schists similar in mineralogical composition, but so completely altered that their origin becomes obscure. The latter may possibly be derived, in part at least, from acid tuffs.

A section from Eldorado creek to Indian river below the mouth of Quartz creek shows a gradual transition from typical fine-grained sericite schists to coarse augen gneisses representing deformed granite porphyries. The gneisses are well foliated and consist of porphyritic individuals of orthoclase, plagioclase and occasionally quartz, scattered through a groundmass of the same materials. Sericite, chlorite and biotite are also present, the latter usually partly chloritized. Epidote and sphene are common accessory minerals and allanite is occasionally found. Similar gneisses occur on the lower part of Sulphur creek and also on the crest of the ridge separating Lower Dominion from Flat creek. In the latter locality, they pass into a coarse-grained augen gneiss, the feldspar lenses often measuring two or three inches in length. In some of the sections here, hornblende is present as well as biotite.

The field evidence of a close genetic connection between the schists and gneisses is confirmed by the microscopic study of thin sections which show all gradations from typical quartz porphyries to granite porphyries.

The following general description of the microscopic character of the sericite schists and associated rocks is contributed by Dr. A. E. Barlow.

"The rocks of the Klondike series are shown, by examination of the thin sections under the microscope, to be altered quartz and granite porphyries. They usually possess a very marked foliation and schistosity accentuated by the development of various secondary minerals as a necessary accompaniment of the pronounced dynamic action to which they have been subjected. The altered quartz porphyries are soft, unctuous to the touch, and have a greenish or yellowish colour and pearly lustre on the cleavage surface, due to the abundant development of the secondary micaceous minerals. The granite-porphyries, on the other hand, are more massive, foliated rather than schistose, are harder and generally vary from grayish to reddish in colour. From a petrographical point of view, both are extremely interesting and instructive as furnishing an undoubted transition from the typical massive types, marking the varieties which have suffered little or no mechanical deformation or alteration, to a nacreous schist or gneiss in which the original phenocrysts of quartz and feldspar have been altogether reduced into lenticular areas, and often fairly continuous bands of granulated material with the development of sericite, chlorite and other products of decomposition along the planes of shearing. As a primary result of the extreme pressure and accompanying stretching to which these rock masses have been subjected, the remaining ungranulated portions of the original phenocrysts of quartz and feldspar, and especially the former, show pronounced wavy or undulous extinction. With an increase of the dynamic metamorphism this condition of strain is relieved by the development of a series of irregular cracks, and the formation of 'tails' of granulated material in the wake of the fragment of crystal. Still further application of the forces of stretching causes the complete obliteration of the original phenocrysts and the production of lenticular areas and broken bands of a comparatively coarse-grained mosaic of quartz and feldspar. The porphyritic individuals of quartz are the first to suffer, and many cases were noticed in which most, if not all of the quartz phenocrysts had undergone advanced granulation, while those of feldspar had suffered little or no deformation. Accompanying such processes of shearing, sericite or hydrous muscovite in pale yellowish or colourless scales and plates is developed in wide, wavy approximately parallel bands sweeping gracefully through and among the individuals of quartz and feldspar. Chlorite, usually accompanied by small crystals, grains and irregular aggregates of epidote and zoisite, is often present, and in some of the more basic and feldspathic varieties, replaces, in large part at least, the sericite. Biotite, either fresh or in the various stages of decomposition into chlorite, is usually present in considerable amount in irregular plates and hypidiomorphic individuals in the granite porphyries. Leucoxene and sometimes the more normal sphene is also very commonly represented in irregular grains derived doubtless from the alteration of ilmenite. Magnetite and pyrite, the latter decomposing to limonite, also occur more sparingly. Occasional crystals and fragments of apatite, zircon and hornblende were likewise noticed. Calcite often occurs and is sometimes abundant in irregular and sharply defined individuals.

"By the failure on the one hand of the quartz phenocrysts and a corresponding increase in the development of those of feldspathic composition, the quartz porphyries show an unbroken transition into the granite porphyries, while on the other hand the frequent abundance of phenocrysts of plagioclase marks a distinct passage into the porphyrites. Silicification or the infiltration and deposition of secondary quartz has likewise contributed much to the formation and consolidation of the rock masses, in many cases effectually masking their original structures. So complete has been this process of hardening that even the most minute cracks and fissures have been completely occupied by the vein-like quartz. The origin of such silica is doubtless pegmatitic, representing the latest, and consequently extremely acid and hydrated, secretions of the magma, evidencing the expiring efforts of the widespread vulcanism to which the enclosing rocks owe their formation. This secondary quartz varies very greatly in the amount and extent of its development, from the small lenticular bands (which can only be detected microscopically and are distinguishable with difficulty from the similar clear areas representing deformed and granulated phenocrysts) to large veins.

"Rocks almost identical in structure and composition have been described in detail by Lawson[1] and Coleman[2] and mentioned by Smith[3] and McInnes[4], as occurring in the district to the northwest of Lake Superior, while Williams[5], on the south of Lake Superior, gives a very minute recital of the structural features noticed in the altered quartz and granite prophyries of the Menominee and Marquette regions of Michigan.

"Similar deformed schistose porphyries have not escaped the attention of the European geologists, and Prof. C. E. Weiss[6] of Berlin in 1884, describes altered quartz porphyries near Thal in Thuringia while Dr. C. Chelius[7], has drawn attention to the very closely related deformed granite porphyries of the Odenwald (Hesse-Darmstadt).

"In some of the areas represented by the typical specimens it is certain that these schistose porphyries are accompanied by acid tuffs, while certain micaceous schists and quartzites, composed chiefly of interlocking grains of quartz with a much smaller, though varying proportion of feldspar and micaceous minerals, may possibly be epiclastic in origin resulting from the consolidation of truly aqueous sediments. If this latter supposition be correct, the application and long continuance of the forces of pressure and stretching, accompanied by complete recrystallization, have produced in all a complete and perfectly interlocking quartzo-feldspathic mosaic, so that nothing can now be asserted, with any degree of certainty, in regard to any structure which they might originally have possessed. The exact diagnosis and correct interpretation of many of these rocks is thus manifestly extremely difficult and in some cases impossible: and even with the advantage of critical study and comparison of the numerous and carefully selected microscopic sections, aided by the detailed field work already undertaken, it has been found hopeless to pronounce decisively regarding the position of some of the examples studied."

Chlorite schists occur both as gradual transitions from the sericite schists and in separate bands alternating with them. In the former case, they doubtless represent the more basic portions of the same rocks from which the sericite schists originated. They are similar to the latter in structural and general character and differ from them, chiefly in containing a greater proportion of chlorite.

The origin of the bands of chlorite schists is not so clear and it is possible that some of them represent later basic intrusions. No direct proof of this is obtainable in the field as both series have been sheared and altered alike, and all the ordinary marks of eruptive contact have been destroyed. The mineral constituents have also been so granulated and altered that little trace of the original structure of the rock remains. Thin sections show areas made of interlocking mosaics of quartz, orthoclase and plagioclase

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[1] Ann. Rept. Geol. Surv., Canada, 1887-88, Part I, pp. 85-90F.
[2] Ann. Rept. Bureau of Mines, Ont., 1894, pp. 84, 87, 88.
[3] Ann. Rept. Geol. Surv., Canada, 1890-91. Report G.
[4] Ann. Rept. Geol. Surv., Canada, 1897. Report H.
[5] Bull. U.S.G.S. No. 26, 1890, pp. 148-154.
[6] Jahrbuch preuss. geol. Landesanstalt für 1883, pp. 213-237, Berlin, 1884.
[7] Notizblatt des Vereins für Erdkunde zu Darmstadt, 4, Folge, Heft 5, 1885, p. 29.

with some calcite, separated by matted aggregates of chlorite and schists arranged in thin curving bands.

Variations from the ordinary type occur in a few places. In the upper part of Dominion creek the schist has a coarser foliation than usual and contains large individuals of quartz and plagioclase in addition to the usual granulated mosaics. Its composition suggests a derivation from a porphyrite. A band of green schist sprinkled with dark hornblende crystals, probably a sheared diorite, crosses the Dome ridge near the head of Bonanza creek, and an actinolite schist occurs on Hunker creek above Goldbottom.

Moosehide Diabase

The rocks referred to under this name outcrop along the lower part of the Klondike valley and on Moosehide mountain, north of the Klondike. They are also found on the western bank of the Yukon valley, opposite Moosehide mountain.

The Moosehide diabase is a greenish medium-grained rock usually sheared. It has yielded less in this respect than the quartz porphyries of the Klondike series and often appears almost massive. It is everywhere greatly altered and in thin sections exhibits great variety. The less altered specimens show a well marked ophitic structure, although the original augite has in most cases disappeared. Secondary hornblende is nearly always present. Occasional small areas and narrow bands consist almost entirely of fibrous actinolite, passing in some places into a coarse asbestos. Serpentine occurs in all the sections, and an almost pure serpentine now represents the original rock on both sides of the summit of Moosehide mountain. Chlorite, calcite and zoisite in varying quantities are common decomposition products, and epidote and sphene, the former often in considerable abundance, are present in most of the sections.

The relationship of Moosehide diabase to the Klondike schists in regard to age is uncertain but it is probable that they are nearly contemporaneous and belong to the same ancient period of igneous activity. The deformation of the diabase is less complete than that of the quartz porphyries, but the constituent minerals have suffered an equal amount of alteration, and both rocks are faulted alike and are traversed by similar small quartz veins.

Unaltered Sedimentary Rocks

Tertiary (Kenai Series?)

Several areas of unaltered sedimentary rocks occur, occupying depressions in and around the outskirts of the Klondike district. The largest of these commences at the Klondike valley above Rock creek and extends in a W.N.W. direction to Cliff creek, a distance of about seventy miles. The width of the area has not been determined but probably averages ten miles. It lies along the base of the Ogilvie range and is separated from the Yukon by a narrow strip of the older schistose rocks.

The rocks consist mainly of slightly coherent sandstones with conglomerates alternating with dark and coloured clays and shales, carbonaceous shales and, occasionally, lignites. No general section has so far been measured and the thickness is unknown. The sandstones are often arkose in character, showing in thin sections angular and subangular grains of quartz, turbid feldspars and colourless micas. Calcite and limonite are also usually present.

The beds dip, as a rule, at moderate angles but are somewhat irregular in this respect, the inclination often changing suddenly, both in degree and in direction. High dips occur occasionally and in places the beds are broken and faulted.

The age of the lignite-bearing beds in the basin has been determined by Dr. Knowlton on the evidence of fossil leaves collected by Mr. A. J. Collier, of the United States Geological Survey, to be Upper Eocene*. They are, therefore, equivalent or nearly so, to the Kenai series.

A small area of Tertiary rocks occurs in the valley of Last Chance creek, just above the junction with Hunker creek. Since their deposition, considerable rock movements have taken place, as they are infolded with the schists on which they rest. The series here, in addition to the usual shales, sandstones and conglomerates, include beds of decomposed andesite tuffs.

Similar beds, cut by andesites and diabases, cover a considerable area south of Indian river, above and below the mouth of Quartz creek. They occupy here a remarkable depression, surrounded on all sides, except where crossed by the Indian river valley, by high ridges built of the older schists. From the centre of the depression rise Haystack mountain and the Dismal dome, two prominent andesite cones, and a number of other lower andesite hills. The origin of the depression is probably due to volcanic action.

The beds in this area are lightly folded and consist of soft light grayish arkose sandstones, yellowish and dark tufaceous sandstones, light and dark shales and clays, agglomerates and conglomerates. In addition to these, a small bed of lignite occurs in a branch of Ruby creek, a tributary of the Indian river. The conglomerate in some places resembles the high-level white channel gravels of Bonanza and other Klondike creeks. It occurs in heavy bands usually associated with sandstones and is often conspicuously white in colour. The pebbles are largely derived from quartz veins and are embedded in a matrix of quartz grains and sericite. They are smaller and better-rounded than the pebbles in the white channel gravel. The conglomerate is usually fairly well indurated, and in places near the andesite masses has been cemented, probably by infiltrating siliceous water, into an exceedingly hard rock. It carries small values in gold and some attempts have been made to mine it.

The shales and sandstone in the Indian River area hold fragments of fossil plants, but none of these have so far been identified.

A large area covered by beds referred tentatively to the Tertiary, but which may be older, occurs south of the district along Sixty-mile river. The apex of this area reaches the Yukon below the mouth of Indian river. Sandstones and shales and andesite and rhyolite tuffs occur, here associated with great sheets of andesite.

Flat Creek Beds

The wide depression between the Klondike hills and the Ogilvie range is covered with alternating beds of silts, sands, clays and gravels, for which the name Flat Creek beds is proposed. These beds have a thickness, on the lower part of Flat creek, of six hundred feet, and a width of from eight to fifteen miles. They extend from a point north of Twelve-mile river S. E. across the Klondike to the Stewart. Between the Stewart and Klondike

* U.S. Geol. Bull. No. 218, p. 25.

rivers, they rest on the older schists and granites, and, north of the Klondike, on the older Tertiary.

The Flat Creek beds have been partially destroyed by streams flowing from the Ogilvie range, and are carved into a series of flat-topped plateaux often lined with low terraces. The beds are nearly everywhere concealed and only a couple of small imperfect sections were seen in the locality visited. These show flat-lying beds of loose gravel alternating with yellowish and grayish sands, sandy clays and silts. The gravels are well-rounded and consist of the slates, cherts, quartzites, diabases, and granites occurring in the Ogilvie range. They are auriferous in places but no pay values have so far been found in them.

The age of the Flat Creek beds is uncertain; they are referred to late Tertiary, but it is possible that a portion of them at least may represent extramorainal material washed out from the Ogilvie range during the glacial period.

Massive Igneous Rocks

Granite

Granite occurs on the Yukon river about three miles below the mouth of Indian river. The area has a width, where cut by Yukon river, of less than two miles, but widens out towards the east. The boundaries of the area as shown on the map are only approximate, as its contact with the surrounding schists is seldom seen. Good exposures occur on the right bank of the Yukon, but the area narrows crossing the valley, and is only found at one point on the left bank.

The granite in this area is grayish in colour when fresh, and coarsely granular in texture as a rule, although in places it becomes distinctly porphyritic. It is usually unfoliated but is slightly sheared in places. Microscopically, it consists essentially of quartz, orthoclase, plagioclase (mostly oligoclase), bleached biotite, and some hornblende, mostly altered into chlorite. The feldspars are usually decomposed and include scales and grains of sericite, and calcite. Almandine garnet is a frequent accessory mineral.

Diabase

An area of diabase three miles in width is cut by the Indian river valley above New Zealand creek. The diabase is a dark-coloured, coarse-textured and quite massive rock. In thin sections it shows a well marked ophitic structure. The lath-shaped labradorite individuals usually inclose brownish augite but occasionally the latter is replaced by greenish serpentine which may have been derived from olivine. Other minerals present include biotite in small quantities, and grains of pyrite and magnetite.

Wide diabase dikes, similar in character to the Indian river diabase, occur in the Yukon valley opposite the mouth of Indian river, cutting rocks referred to the Tertiary, and several small dikes cross Eldorado creek near its mouth, cutting the Klondike schists. Thin sections of these show, in addition to the usual minerals, large apatite prisms.

Andesites, etc.

Andesite dikes and stocks are common in the Klondike district, and rocks representing andesite-flows are also prominent. The andesites cut the old schistose rocks in places, but usually occur in connection with the Tertiary beds. Some of them are younger than the latter while others appear to be contemporaneous with them. Tufaceous beds, usually andesitic in character, occur on Last Chance creek and other places, interbanded with the shales and sandstones of the Tertiary series.

The largest andesite area in the district occurs in the Tertiary depression south of Indian river. Two prominent elevations which rise from this depression, known as Haystack mountain and the Dismal dome are built entirely of this rock, and it also spreads over a considerable part of the bordering lowlands. Haystack mountain evidently represents the core of an old volcanic centre partially destroyed by erosion.

The andesite from Haystack mountain is a grayish, moderately fine-grained, and often distinctly porphyritic rock. In thin sections it shows a microfelsitic ground mass usually more or less decomposed. In this are embedded long tabular crystals of plagioclase and large rounded individuals of greenish hornblende bordered by opaque rings consisting of ilmenite and leucoxene. Augite is also usually present and, less frequently, scales of brownish biotite.

A second area of andesites, largely effusive in character, occurs on the Yukon river opposite and below the mouth of Indian river. The andesites, associated with Tertiary sedimentary rocks, are exposed along the left bank for several miles, and at one point, cross the Yukon valley and spread out along the foot of the slope on the right bank. The rock here is vesicular, the cavities often containing chalcedonic material. It is a hornblende-augite-biotite andesite very similar to the Indian river variety. The ground mass is less individualized and includes some glassy matter. The andesites on the left bank of the Yukon are traversed in places by wide diabase dikes.

A small area of hornblende andesite borders the Tertiary area at the mouth of Last Chance creek. The andesite here is coarser-grained than usual and is badly decomposed. In thin sections it shows a felted ground mass of plagioclase and hornblende, the latter often altered into chlorite.

A light gray medium-grained granular rock occupying a small area on Whiskey hill on Upper Hunker creek, is very similar in structure and composition to Richthofen's 'propylite'*. The plagioclase individuals of which it principally consists have a rude, ophitic structure, the interspaces being filled largely with unstriated feldspar and quartz, and less frequently with brown biotite and green hornblende, the latter often in perfect crystals. Magnetite, apatite and sphene are also present.

A somewhat similar rock was found on Indian river, apparently passing into the andesites, of which it probably represents a deep-seated phase.

Quartz Porphyries, etc.

The quartz porphyries are the youngest igneous rocks in the district. They occur in numerous, small, oblong areas, everywhere throughout the region, both in the valleys and on the ridges. The areas usually measure from one to two hundred yards in width and from a quarter to half a mile in length, and might be classed in most cases as wide, short dikes. They were found to be intrusive through the schists and older rocks in all cases where contact exposures were available for study.

The quartz porphyry, macroscopically, is a pale yellow compact rock sprinkled with small phenocrysts of dark quartz and yellowish decomposed feldspar. In thin sections it shows a microgranitic ground mass through

* Mem. California Acad. of Sci. Vol. I, part II, 1868.

which individuals of quartz, orthoclase and plagioclase are porphyritically distributed. Quartz is the most abundant porphyritic mineral, and occurs both in rounded and corroded forms and in perfect dihexahedral crystals. The feldspars usually exhibit good crystallographic outlines.

The various dikes and areas of the recent acid volcanic rocks dotted over the district agree, as a rule, very closely in character, but in a few cases the microgranitic ground mass is replaced by a glassy base, and the rock might be classed as a rhyolite rather than as a quartz porphyry. A specimen from a small area, probably effusive in character, situated on the right bank of the Klondike river, seven miles above Rock creek, showed, in thin sections, a glassy ground mass with fluidal structure, holding microlites and spherulites of quartz and feldspar. The porphyritic individuals, in addition to those in the quartz porphyries, included occasional scales and plates of brown biotite.

Serpentines (Peridotites)

A long narrow band of serpentine occurs on the ridge separating the upper part of Hunker creek from the Klondike river. At the head of Leotta Creek it rises into a prominent peak known as Leotta mountain. The serpentine lies near the northern boundary of the Klondike schists, and cuts both these and the dark schists of the Nasina series.

The serpentine in Leotta mountain is a dark greenish, compact rock, often weathering into yellow and brown shades. In places the green base is mottled with yellow, the latter representing the less altered portions. Thin sections exhibit occasional cores of brownish pyroxene and almost colourless olivine, showing that the rock originated from a peridotite. Some calcite is also usually present, and grains of dark iron ore (probably magnetite) occur in most of the sections.

The intrusion of the peridotite occurred at a comparatively recent period, as it has not been sheared, and is not traversed by the veins and dikes which cut all the older rocks.

A second serpentine area occurs on the summit of the Hunker Klondike ridge, nearly opposite the mouth of Hester creek. The serpentine here is a harder and much tougher rock than that occurring at Leotta mountain. In thin sections it is seen to consist of small scales and fibres of greenish serpentine, matted together in an extremely intricate manner. No cores of the original minerals were observed. The contact of this mass with the surrounding schists was not seen.

Gravels of the Klondike Gold Fields

A section across the valley of any of the gold-bearing streams entering the Klondike shows a comparatively narrow trough-like depression below, from 150 to 300 feet deep, bordered on one or both sides by wide benches beyond which the surface rises in easy, fairly regular slopes up to the crests of the intervening ridges. The benches represent fragments of older valley-bottoms partially destroyed by the excavation of the present valleys. Narrow, rock-cut terraces occur at intervals between the level of the old valley-bottoms and the present level.

Auriferous gravels occur on the present valley-bottoms, on the portions of the old valley-bottoms still remaining and on the rock terraces cut into the slopes connecting them. They may be classified as follows, beginning with the youngest.

Low level gravels.	Gulch gravels.	
	Creek gravels.	
	River gravels.	
Gravels at intermediate levels.	Terrace gravels.	
High level gravels.	River gravels.	
	White channel gravels.	White gravels.
		Yellow gravels.

Low Level Gravels

The low level creek gravels are the most important gravels in the district. These gravels floor the bottoms of all the valleys to a depth of from four to ten feet. They rest on bedrock usually consisting of decomposed and broken schists, and are overlaid by a sheet of black frozen muck ranging in thickness from two to thirty feet or more. They are local in origin and consist entirely of the schists and other rocks outcropping along the valleys. The schist pebbles are usually flat round-edged discs measuring one to two inches in thickness and two to six inches in length. They constitute the greater part of the deposit, but are associated with a varying proportion of rounded and subangular quartz pebbles and boulders, and, less frequently, with pebbles derived from the later eruptive rocks of the region. The pebbles are loosely stratified, are usually embedded in a matrix of coarse reddish sand and alternate in places with thin beds of sand and muck.

The creek gravels frequently inclose leaves, roots and other vegetable remains and also the bones of various extinct and still existing northern animals, such as the mammoth, the buffalo, the bear, the musk-ox and the mountain sheep and goat.

The gulch gravels occupy the upper portions of the main creek valleys and small tributary valleys. They differ from the creek gravels in being coarser and more angular. A considerable proportion of their material consists of almost unworn fragments of schist washed down from the adjacent slopes. They contain the same vegetable and animal remains as the creek gravels.

The only river gravels of the district proven, so far, to contain gold in paying quantities occur in the wide flats bordering the lower portion of the Klondike river below the mouth of Hunker valley. The river gravels consist of quartzite, slate, chert, granite and diabase pebbles largely derived from the western slopes of the Ogilvie range. They are harder and better-rounded than the creek gravels, a necessary result of the greater distance travelled.

Terrace Gravels

Rock terraces occur at various points cut into the steep slopes of the present valleys. They were produced during the deepening of the valleys, and are simply remnants of former valley-bottoms. They are small, seldom exceeding a few yards in width and a few hundred yards in length, irregular in distribution, and occur at all elevations up to the bottoms of the old valleys. The terraces support beds of gravel, usually from six to fifteen feet in thickness, very similar to those in the creek bottoms, but showing somewhat more wear. The terrace gravels, like the creek gravels, are overlaid, as a rule, with muck, and at one point on Hunker creek were found buried beneath a hundred feet of this material.

High Level Gravels

High level river gravels are extensively distributed along Bonanza and Hunker creeks and some of their tributaries, and also occur on Eldorado, Bear, Quartz, Nine Mile, and Allgold creeks. They consist, principally, of ancient creek deposits, overlaid near the mouths of some of the valleys by gravels laid down by the Klondike river, when it ran at a much higher level than at present, and occupied a somewhat wider valley.

These gravels occur at various points along the Klondike river. In the Klondike district they are found covering the small plateaux in which the ridges separating Bonanza and Hunker creeks from the Klondike river terminate. They rest, in both places, on high level creek gravels at an elevation of about 450 feet above the present valley-bottoms. They have a thickness of from 150 to 175 feet, and consist principally of well-rolled pebbles, of quartzite, slate, chert, granite, diabase and conglomerate embedded in a matrix of gray sand and derived, like those in the present stream, from the western part of the Ogilvie range. The high level river gravels are reported to contain gold in paying quantities at Acklens farm, a name given to a portion of the bench on the right limit of the Klondike, two miles above its mouth, but are generally of little economic importance.

The high level creek gravels consist principally of the important deposit known as the quartz drift white wash or white channel gravels. The latter name is now generally used by the miners, and is adopted in this report.

The white channel gravels are ancient creek deposits laid down in the wide, flat-bottomed valleys which characterized the region previous to the last general upraise. After their deposition, the country was elevated 600 to 700 feet, and the increased grades acquired by the streams enabled them to cut down through their old gravel beds into the bedrock beneath, and to excavate the steep-sided trough-like valleys in which they now run. The old gravels now occur on wide benches bordering the present valleys at elevations of from 150 to 300 feet above them, the elevation generally increasing down stream. Their distribution along the valleys is irregular, as a large portion of the deposit was destroyed during the deepening of the main valleys and the tributary valleys and gulches.

The general character of the white channel gravels is remarkably similar in the various Klondike creeks, but differs considerably from the ordinary type of stream deposits in other regions. They consist of a compact matrix of small, clear, little-worn and often sharply angular grains of quartz and scales of sericite thickly packed with rounded quartz pebbles and rounded and sub-angular and wedge-shaped quartz boulders often two to three feet in diameter. Flat and sub-angular pebbles of sericite schist, the principal rock of the district, are also present, but in much smaller numbers than the quartz constituents. The schist pebbles are usually decomposed and crumble rapidly when thawed out. The deposit is always stratified, but, except in rare instances, there has been no sorting of the various constituents into separate beds, and the composition is very uniform throughout. The colour is characteristically white or light gray due to the preponderance of the quartz constituents and the leaching out of the greater part of the iron. The colour is darker and the sands are noticeably coarser towards the limit of the deposit on the upper part of the creeks.

The white channel gravels vary in thickness from a few feet to 150 feet and in width from 100 feet to half a mile or more. The deposit increases in volume descending the streams, and attains its greatest development near their mouths.

The white compact gravel deposit described above is overlaid in places by loosely stratified gravels known as the yellow gravels. The latter are of a rusty colour, are more distinctly stratified than the white gravels and consist mainly of flat schist pebbles lying loosely in a coarse sandy matrix. Quartz pebbles and boulders are also present, but are much less abundant than in the white gravels.

These upper gravels are not so widely distributed as the white gravels but are present on several of the Bonanza hills and at points along Hunker creek. At Gold hill, on Bonanza creek, the white gravels occur as a buried ridge bordering the present valley, and the depression between them and the southern slope of the old valley is filled with yellow gravels to a depth of 115 feet. The same relationship between the two deposits obtains at Adams hill and probably at other places, but is only determinable where shafts have been sunk to bedrock across the whole width of the old valley.

Unlike the creek gravels, the white channel gravels are destitute, or nearly so, of vegetable and animal remains. None were found by the writer and the few reported discoveries of fragments of wood and bone by miners are all open to question.

On Dominion creek and its tributaries, Sulphur and Gold-run creeks, white gravels, almost identical in character with the high level white channel gravels of Bonanza and Hunker creeks, occur in the bottoms of the valleys underlying the present stream gravels. Their low position is due to the fact that the present valley of Dominion creek, corresponds, not to the present valley of Bonanza and Hunker creeks, but to the old valleys cut through by them.

The peculiar character of the white gravels has led to considerable diversity of opinion in regard to their origin: they have been attributed to ice, stream, lake and fiord action. In some of the sections, they bear a close resemblance to coarsely stratified till, but no evidences of glaciation have been found in the region. They could not have been deposited in still water, as they occur following steep valleys, heading closely together and running in opposite directions, and they differ from ordinary stream deposits in their compactness, white colouration, and imperfect bedding and differentiation of material.

They are now regarded by the writer, although a different view was formerly entertained, as stream gravels deposited under somewhat peculiar conditions, chief among which was an exceedingly slow accumulation in streams of easy grades and comparatively slack currents. In the present streams, the schist pebbles greatly outnumber those derived from the quartz veins, while in the old streams the proportion is reversed, although both derived their supply from the same hillsides. The wash of the old streams is thus, in some respects, a residual deposit composed largely of the more resistant constituents originally present, the softer rocks having been eliminated either by abrasion in the bed of the stream or by the slow process of decomposition.

The white channel gravels are much older than the other gravels in the district and probably date back to the Pleocene at least. They were almost certainly deposited when milder climatic conditions than at present prevailed, as the leaching out of the greater part of the iron, and the decayed condition of the schist pebbles must be attributed to surface waters, and no circulation of these was possible if the gravels, like those in the present streams, had been frozen together as soon as deposited.

Gold-Bearing Creeks Tributary to Klondike River

Bonanza Creek

Bonanza creek is the most important of the gold-bearing creeks of the Klondike district, and is the one on which gold in large quantities was first discovered. It heads in the Dome ridge with branches of Quartz and Hunker creeks and empties into the Klondike river three quarters of a mile above Dawson, after a course in a N.W.N. direction of a little over seventen miles. It has a drainage area of approximately 113 miles. It is a comparatively small stream even near its mouth, where it measures, in ordinary stages of the water, about fifteen feet in width by three or four inches in depth on the bars. It flows, however, in a steady stream and seldom furnishes less than one sluice head of water throughout the season, all along the productive part of the valley. The principal tributaries are Eldorado creek, Adams creek, Boulder creek, Forty-nine creek, Sourdough gulch on the left, and Carmacks fork, Homestake creek, Gauvin creek, Queen gulch and Mosquito creek on the right.

The valley of Bonanza creek is characterized chiefly by its markedly angular trough-like shape. The present valley has been cut down in the floor of an older valley and that rapidly and almost continuously, as shown by the steep lateral walls and the absence of continuous lines of terraces in the newer valley. The present valley usually shows a flat bottom of varying width commonly measuring from 300 to 600 feet, bounded by steep sides 150 feet high at the Eldorado forks, and gradually increasing in elevation down the valley, or, with a steep wall of the same height on one side and an easier slope on the other. It follows a sinuous line bending with short curves round points that project alternately from either side. The present valley is excavated, as a rule, along one side of an older and much wider valley, and the general effect produced is asymmetrical. On one side the slope is broken, at an elevation, usually, of from 200 to 300 feet, by a rough plain of irregular size, but often a third of a mile wide, beyond which is an easy ascent of a thousand feet or more to the summit of a bordering ridge, while, on the other side, the slope, though varying in steepness, is continuous throughout.

The plain of the older valley is not noticeable in the upper part of the present valley, but becomes a marked feature at McKay creek, three miles above the mouth of Eldorado creek, and is then traceable along the right bank down to the Eldorado forks. At the forks it crosses to the left and follows the left bank to Sourdough gulch, then re-crosses and continues on down the right side to the point of the ridge separating Bonanza creek from the Klondike river. Above McKay creek, the slopes of the valley become more uniform, but continue, for some distance, steeper on the left side than on the right.

The grade of the older valley is less than that of the modern one. The rim of the older valley at McKay gulch is 110 feet above the present valley-bottom; at the forks it is 150 feet and at the mouth its elevation is increased to about 300 feet. The grade of the present valley below the forks averages about fifty feet to the mile, and that of the older valley thirty-three feet to the mile. Between Eldorado forks and the Carmacks forks, the grade of the present channel averages one hundred feet to the mile and further up increases rapidly. Besides the plain of the older Bonanza valley, a number of more recent terraces occur at lower elevations. These terraces are rock-cut as a rule, are usually quite narrow, are only traceable for short distances, and recur at irregular distances. They are found at intervals all the way from Lovett gulch up to Victoria gulch.

Country Rocks

The rocks along Bonanza creek consist almost entirely of the light-grayish and greenish sericite schists of the Klondike series, alternating in the upper parts with bands of green chloritic schists. Narrow bands of dark graphite schists cross the valley above the mouth of Adams creek and at one or two other points. The sericite schists are often silicified and inclose numerous small quartz veins.

Gravels

All the gravels enumerated on page 82 are represented on Bonanza creek. In order of economic importance the present valley gravels come first, then the high level white gravels, followed by the terrace gravels. The high level river gravels and the yellow gravels have not proved productive.

The valley gravels consist of clean, flat, fairly well-worn pebbles, mostly from one to six inches in length and one to two inches in thickness, derived from the light-grayish and light-greenish micaceous schists of the neighbourhood, associated with rounded and subangular pebbles of quartz and, occasionally, large quartz boulders usually angular in form. A few pebbles of dike-rock are generally present. The material is wholly of local origin and is derived from the rocks outcropping along the valley. The pebbles are roughly shingled up stream, lie in a matrix of coarse sand and are occasionally interstratified, especially above, with beds of sand. They rest on the floor of broken and decomposed bedrock, into which the gold has often penetrated to a depth of three or four feet. The gravels form a fairly uniform covering of from four to eight feet in thickness all across the flat bottom of the valley. Their width varies with the enlargements and constrictions of the valley, but usually measures from 300 to 600 feet, with occasional enlargements to 900 feet or more. The width increases gradually but irregularly down the valley.

They are overlaid everywhere by a bed of black frozen muck from five to fifteen feet in thickness. The muck occurs in most places in a massive bed, but is also found interbanded with layers of sand. Small beds of impure muck occur in places alternating with the gravels almost down to bedrock.

The terrace gravels have a general resemblance to the stream gravels. They are formed of the same materials, but the pebbles show, as a rule, more wear. They are roughly stratified and include beds of small pebbles and sand, often showing cross-bedding. The terrace gravels have a limited distribution. They rest on short, narrow rock-shelves distributed irregularly along the valley, on flat projecting points; or are built up at the mouths of gulches and streams. They are uncovered at some points, and, in other places, are deeply buried beneath an accumulation of muck and rocky *débris* from the sides of the valley.

The white gravels, which, with the associated yellow gravels, floor the older and more elevated Bonanza valley, have been described generally on a previous page. This unique and important deposit is extensively, but not continuously, distributed along Bonanza creek. It is necessarily absent where the ancient and modern valleys coincide, and has also been swept away in other places by erosion. It is found descending the creek, covering small areas below McKay creek and Homestake creek and a much larger area below Gauvin gulch. At the latter place it rests on a nearly level rock floor at an elevation of about 140 feet above the present valley-bottom. It occurs uncovered along the edge of the valley, but farther back is buried beneath an accumulation of loosely stratified gravels and sand. The total width of both deposits at this point measures approximately 2,000 feet and the depth ninety feet. A shaft sunk to bedrock, 450 feet back from the rim, showed fifty-five feet of the loose upper gravels and thirty feet of the compact white gravels. The gravels of the old valley extend from Gauvin gulch down Bonanza creek almost to Eldorado forks, but the upper gravels only are present along part of this distance, and are also traceable in a narrow disconnected band up Gauvin gulch for a considerable distance at an elevation of about 100 feet above the valley-bottom.

At Eldorado forks, the plain of the old valley crosses to the left side of Bonanza creek. A small patch of gravel has been left on the point of the ridge separating the two creeks, and, immediately opposite the forks and extending for some distance up Eldorado creek and down Bonanza creek to Big Skookum gulch, is the important Gold hill deposit. The gravels here cover an area about half a mile in length by 2,000 feet in width and have a maximum thickness of about 116 feet. The white gravels outcrop at an elevation of 150 feet above the bottom of the valley and appear, so far as one can judge by the shafts, to form a great ridge following the edge of the valley, a hundred feet or more in height and 500 to 600 feet in width, with the hollow behind filled up with the yellow gravels. The rock surface on which the gravels rest is roughened with small hollows and ridges. It extends back from the river at nearly the same general elevation for several hundred yards; then it rises somewhat abruptly to the surface.

The white gravels are absent between Big Skookum and Little Skookum gulches but come in again below the latter on Adams hill and continue to Adams creek. The gravels on Adams hill have a width of 2,000 feet and a depth, 550 feet back from the rim, of 130 feet. The arrangement of the white and yellow gravels is similar to that on Gold hill. Below the break formed by the valley of Adams creek, high level gravels occur pretty constantly, except where cut away by gulches, all the way down to Fortynine creek; and at one point below Mosquito creek they cross the valley and appear in a band 450 feet wide and ten to twenty feet in thickness on the right hand side. The thickness of the deposit on the left limit often exceeds 125 feet. The width is variable but usually measures from 1,200 to 2,000 feet.

Below Fortynine creek, the deposit becomes less continuous for some distance. A small patch occurs below the mouth of Fortynine creek; a second opposite claim 57, below Discovery; and another, the last, on the left limit below Sourdough gulch. At the latter point it crosses the valley to the right limit above Cripple creek and continues down, gradually increasing in width, past Trail and Lovett gulches and across the plateau in which the ridge separating Bonanza creek from the Klondike river terminates, to the valley of the latter. The volume of the deposit becomes greatly increased after crossing the valley. Its thickness on the hill between Trail and Cripple creeks is 225 feet, and on Lovett gulch is not less than 150 feet. The width, near the mouth of the valley, is over half a mile.

High level river gravels occur on both sides of Bonanza creek near its mouth. On the right limit they rest on the white channel gravels and on the left limit on rock benches. They have a thickness of from 150 to 200 feet and are found up to an elevation of 700 feet above its present valley-bottom. No gravels of any kind were found above this level. The high level river gravels differ from the creek gravels in being well-rounded and in consisting of foreign material, principally slate, quartzite, diabase, etc., mostly obtained from the sources of the Klondike river.

Gold Contents of Gravels

The creek gravels of Bonanza valley have proved productive from Victoria gulch down to the mouth of the creek, a distance of about thirteen miles. The gold is distributed along the creek in a somewhat erratic manner. No claims have been worked at a profit from the head of the creek down to claim No. 43 above Discovery, at the mouth of Victoria gulch. No. 43 and the succeeding six claims going down stream, were good producers, and the ten claims following, Nos. 36 to 25, all proved remarkably rich. Some of these 500-foot claims have yielded upwards of half a million dollars each, or at the rate of over $1,000 per running foot of valley. The gold tenor of the gravels decreases approaching Eldorado forks, but increases again below the forks. A short stretch of the creek above Discovery claim, half a mile in length, was exceedingly rich and in spots almost fabulously so. A fraction at the mouth of Little Skookum gulch, about eighty feet in length, commonly known as Dick Low's fraction, is reported to have yielded over $300,000. The claims below Discovery down into the fifties all yield well. In the lower part of the creek, the gold in the gravels becomes finer and less plentiful, but there are few claims, if any, right down to the mouth of the creek, which cannot be worked at a profit under present conditions.

The Bonanza creek stream gravels, below Victoria gulch, are seldom entirely barren, and along the more productive portions of the creek have been worked from rim to rim across the whole width of the valley-bottom. The values are irregular but are not confined to one particular pay-streak, and are usually largely dependent on the condition of the bedrock. Where this is smooth and soft, the gold slips along it, and is collected where the harder schists form natural riffles. The gold occurs both in the gravel and in the underlying shattered bedrock. From two to four feet of bedrock are usually mined and washed and from four to six feet of gravel.

The white channel gravels are scarcely inferior in economic importance to the creek gravels. Claims of varying richness, often several tiers deep, have been staked on this deposit wherever it occurs, all the way from McKay gulch down to the lower end of the valley. The most productive part extends from Eldorado forks down stream to Boulder creek, a distance of three miles. In this stretch, a pay-streak nearly 1,000 feet in width in places, has paid to work by methods entailing an expenditure of from four to six dollars per cubic yard of material mined. In the early days of the camp, when rocking was the only means of working the gravel, the cost was even greater. In the richest places whole claims are reported to have yielded over sixty dollars per superficial yard, while values of from twenty to forty dollars per square yard of surface were common. In the lower part of the valley the values are less, but claims have been staked and worked at a profit as far down as Lovett gulch.

The distribution of the gold in the white channel gravel follows the usual rule in creek gravels. It is mostly concentrated in the lower three to five feet of gravel and the underlying one to two feet of bedrock. The bedrock, while more decomposed, is not shattered so badly as in the present creek channel, and the gold has not descended so far. The upper surface of the pay gravel is irregular, and in some instances the pay has been followed upward eight to ten feet or more above bedrock. In places where the bedrock is uneven, the gravels on the summits of the wavy elevations usually carry greater values than those in the depressions.

While the greater part of the gold in the white channel gravels is found close to bedrock, the deposit carries some values throughout and it is this fact which gives it such great importance in view of future hydraulicking operations. Less than half per cent of the total volume of the deposit, estimated at 250,000,000 cubic yards on Bonanza creek alone, has been worked or is workable by the drifting method.

The terrace gravels of Bonanza creek yielded well while they lasted, but occurred in small deposits and were soon exhausted. The yellow gravels associated with the white gravels and the high level river gravels have not proved remunerative with present methods.

Character of Gold

Bonanza creek gold occurs in coarse, rough, usually flattish grains in the upper part of the creek and in similar but smaller scales in the lower part. Nuggets are obtained occasionally from most of the claims but are not plentiful, except near the mouth of Little Skookum creek. They are small, as a rule, seldom exceeding half an ounce in weight, and no very large ones have been found. The nuggets are often crystalline in character and nearly always inclose grains and fragments of quartz. The value of the gold above Eldorado creek averages about $16.75 per ounce. Below Eldorado creek, the value drops to about $16.00 per ounce and in the lower part of the creek is about $16.25 per ounce. The gold in the white channel gravel is lighter in colour than in the creek gravels, is slightly lower in grade and is more angular and includes a large proportion of nuggets.

The tributaries of Bonanza may be separated into creeks occupying flat-bottomed valleys and those in V-shaped gulches. None of the larger creeks, with the exception of Eldorado creek, which is described separately, have yielded much gold. Adams creek enters Bonanza creek a mile below Eldorado creek on the same side. It is nearly equal in size to Eldorado creek, cuts the same rocks, and its valley is almost precisely similar in general character, yet one creek ranks among the greatest producers ever discovered, while the others have yielded only insignificant amounts. A few claims have been worked on Adams creek below the mouth of Stampede gulch, and some gold has been taken out, but no continuous pay-streak has been discovered. Boulder creek, two miles below Adams creek, is also similarly barren except for a short distance near its mouth. In upper Bonanza, Gauvin and Homestake creeks are both worked to some extent for a couple of miles above their mouths. The plain of the old valley extends up the former nearly to its head, and carries pay gravels in places.

Among the more important Bonanza gulches are Victoria, O'Neil and

Ready Bullion, on upper Bonanza; Big Skookum, Magnet, American, Fox, Monte Christo and Lovett gulches on lower Bonanza.

Victoria gulch, the most productive of the upper Bonanza gulches, enters Bonanza creek from the left, one and three quarter miles below Carmacks fork and almost at the head of the productive part of the creek. It heads with Gay gulch, a gold-bearing tributary of Eldorado creek. It is about two miles in length and, in character, conforms strictly to the gulch type. At the head is a steep regular amphitheatrical depression leading into a narrow angular valley that gradually enlarges down stream. It has a fall of about nine hundred feet. The narrow gutter-like bottom of the valley is covered with from two to seven feet of coarse angular gravel and slide rock, overlaid by a few feet of muck. The gold from this gulch is coarse, and in the upper part was exceedingly rough and angular, and looking as if it had just dropped out of crevices in the quartz.

A small tributary of Victoria gulch, known as No. 7 pup, has also been found gold-bearing for a distance of half a mile above its mouth. It joins Victoria gulch on No. 7 claim and is simply a shallow depression in the hill-side. It has a steep grade rising four hundred feet in the first seventeen hundred feet of its course. The gravel is angular and consists principally of almost unworn slide rock. The gold is also coarse and angular and includes some large nuggets. A flat, oblong, unworn nugget, found on No. 7 claim, weighed four and a half ounces.

Ready Bullion and O'Neil gulches are similar in character to Victoria gulch. Both yielded small amounts of gold.

The productive lower Bonanza gulches, between Adams and Boulder creeks, differ in some respects from those just described. They cut through the white channel gravels and have not proved productive, beyond the edge of this deposit. The rich claims near their mouths have evidently derived their supply of gold from the older gravels and not from original sources. Big Skookum gulch, above Adams creek, was similarly enriched near its mouth with gold concentrated from the white channel gravels, but a few claims near its head also contain coarse angular gulch gold.

Eldorado Creek

Eldorado creek, the most important tributary of the Bonanza creek, is a small stream about seven miles in length and from three to six feet in width at its mouth. It carries, late in the season, barely a sluice head of water. The valley is flat-bottomed for three or four miles above its mouth, but narrow, the flats seldom exceeding 300 feet in width. The present valley is excavated, like Bonanza creek (of which it is a continuation) in an older and wider one. It shows the same characteristics as Bonanza valley, having a trough-like depression below, 150 feet deep and from 225 to 450 feet in width, above which the slope is continuous and fairly steep to the summit of the ridge on the right limit, but on the left is interrupted by the plain of the old valley, usually about a quarter of a mile in width. Beyond the plain the upward slope recommences, but at a lower angle. The plain of the old valley follows the left bank of Eldorado creek for two miles above its mouth. Above this it follows the right bank to a point above Oro Grande gulch, where it disappears. The upper part of the valley, from Chief gulch upward, is narrow, steep and V-shaped. Narrow terraces occur at intervals in the lower part of the valley, but do not form a conspicuous feature.

Country Rocks

A few narrow diabase dikes cross the lower part of Eldorado creek, and narrow bands of dark graphitic schists were noticed in one or two places, but with these exceptions the valley is cut altogether out of the light-coloured micaceous schists of the Klondike series. Quartz veins are everywhere present, some carrying free gold.

Gravels

The Eldorado creek gravels are precisely similar to those on Bonanza creek. They consist of from five to nine feet of flat schistose, and angular or rounded quartz pebbles, covering the bottom of the valley in a fairly uniform sheet, overlain by a few feet of frozen muck.

The white channel gravels have an elevation above the present valley bottom, at the mouth of the creek, of 150 feet, and three miles farther up, where they disappear, of 125 feet. They consist, as on Bonanza creek, of a white compact deposit below and an upper series of stratified flat pebbles overlying these. Areas of white gravels occur at the mouth of Eldorado creek, forming part of the Gold hill deposit previously described, and on French hill, immediately below French gulch, while smaller patches occur about half a mile below French gulch on the same side, and half a mile below Gay gulch on the right limit. At the latter point, the deposit occurs for the last time ascending the creek. It is quite narrow and has a thickness of only eighteen feet. It lies in a shallow-pitted channel-like depression running parallel to the present valley. At French hill it has a thickness, including the upper gravels, of over a hundred feet. The occurrences between French hill and Gold hill are small and unimportant.

Gold Contents of Gravels

Eldorado creek has proved the richest creek in the Klondike district and one of the greatest placer creeks ever discovered. The claims are numbered from the mouth up, and are approximately 500 feet in length. The first thirty-seven claims, with a few intervening fractions, have yielded gold of an estimated value of between twenty and twenty-five million dollars and several millions will be added to this amount before the creek is exhausted. The most productive portion of the creek extends from its mouth up the Gay gulch, a distance of about three and a half miles. The gravels on this stretch, with the exception of those on claims 34 and 35 and on claims 18 to 21, were all extraordinarily rich. No. 17, at the mouth of French gulch, reputed to be the richest claim in the whole district, has yielded nearly a million and a half dollars worth of gold, and claims Nos. 5, 16 and 30 almost rival it in importance. Above Gay gulch the gold in the gravels diminishes in quantity and is more erratic in its distribution, but mining has been done up to the mouth of Chief gulch and a narrow pay-streak, carrying values in places, has been traced for some distance beyond. The pay gravels of Eldorado creek, like those on the greater part of Bonanza creek, extend, although the values vary somewhat, across the whole width of the valley-bottom. They are shallow, seldom exceeding four to six feet in thickness. A considerable proportion of the gold occurs in the partings of the underlying schistose bedrock and from two to four feet of this is usually mined and washed. Terrace gravels, often moderately rich, occur along the valley at intervals from Gay gulch down to the mouth.

The white channel gravels are less important than on Bonanza creek.

Part of the rich Gold hill occurrence of this deposit, previously described, extends up the valley of Eldorado creek. A number of the claims on French hill also proved very rich and fair results have been returned from the occurrence above Oro Grande gulch.

Eldorado gold is very coarse and is often angular and almost unworn. Nuggets are more plentiful than on the other creek, and are often crystalline in form. Several nuggets, valued at from $400 to $1,000, have been obtained from the upper part of the pay streak. The gold is lighter in colour and of a somewhat lower grade than on Bonanza creek, the assay value usually varying from $15.50 to $15.75 per ounce.

Tributaries of the Eldorado

The tributaries of Eldorado creek, like those of Bonanza creek, are comparatively unimportant. Some gold has been obtained from Gay gulch, Nugget gulch, the lower part of French gulch, and from claim No. 6, on Chief gulch. The gulches are steep, and most of the gold received by them from the hillsides has been carried down into the main valley.

Hunker Creek

Hunker creek is a tributary of the Klondike, into which it empties, six miles above the mouth of Bonanza. It heads close to the Dome, with Dominion creek, and flows in a north-westerly direction. It has a length of fifteen miles, and is about equal in size to Bonanza creek. The most important tributaries are Last Chance and Goldbottom creeks, both of which come in from the left.

Valley

The valley of Hunker creek is remarkably similar to that of Bonanza creek, and, like it, its present form is due to a secondary valley sunk in the floor of an older one. The recent valley, near its mouth, is sunk through 100 feet of gravel and 300 feet of bedrock. It is a steep-sided, flat-bottomed trough, two to four hundred yards wide near the mouth, but gradually narrowing up stream. Its width is more irregular than Bonanza valley, and the basins developed at intervals in the lower part are wider. The plain of the old valley is a marked feature from the mouth up to a point a mile above Goldbottom creek, a distance of eight miles. It disappears there, but comes in again for a short distance a mile and a half farther up.

A few rock-cut terraces occur below the plain of the old valley, but are seldom very conspicuous. Like those on Bonanza creek, they are narrow, irregular in height, and usually quite short.

Country Rocks

The rocks along the upper part of Hunker creek consist of the light coloured sericite schists and the greenish chlorite schists of the Klondike series, cut in places by small areas of recent volcanic rocks, principally andesites and quartz porphyries. From Colorado creek down nearly to Henry gulch, the dark quartz-mica schists of the Nasina series occur most frequently. An area of Tertiary sedimentary rocks, associated with andesite, outcrops at the mouth of Last Chance creek. Above Henry gulch, the rocks of the Klondike series reappear and continue to the mouth of the creek.

Gravels

The gravels on Hunker creek, like those on Bonanza creek, are of four different kinds, viz., the present creek gravels, the terrace gravels, the white channel gravels and a sheet of high level river gravels overlying the white channel gravels near the mouth of the valley.

The creek gravels are all local in origin, and are similar in character to the Bonanza creek gravels. They consist of flat schistose gravels, subangular quartz pebbles and boulders, and occasional pebbles derived from the newer eruptive rocks. They have a thickness of from four to ten feet, and are overlain by from five to twenty feet of muck or peaty material. At Discovery claim, the thickness of both muck and gravel is, for a short distance, less than ten feet.

The terrace gravels are more rounded than the creek gravels, but are otherwise very similar. They occur in narrow, disconnected strips along both sides of the valley, at various elevations up to 200 feet above the present valley-bottom. They have a maximum thickness, in the sections examined, of seventeen feet, and, in places, are of considerable economic importance.

The white channel gravels have a wider distribution along Hunker creek than on any other creek in the district. They commence, descending the valley, in a comparatively thin narrow band on the right limit opposite number four below Discovery, where they occupy a basin-shaped depression on both sides of number six gulch. They are absent below this point for some distance, but reappear on the left limit half a mile above Goldbottom creek, and continue down on the same side, except when broken through by the valleys of the larger tributaries, to Henry gulch, near the mouth of the valley. A few small patches also occur on the right limit between Goldbottom and Hester creeks. Below Last Chance creek the main deposit crosses Hunker valley and continues through in a wide band to the Klondike valley.

The character of the white channel gravels on Hunker Creek is very similar to that on Bonanza creek. Where typically developed they form a grayish, almost white, compact deposit, consisting mainly of sericite, clear angular quartz grains, quartz pebbles and boulders and a few schist pebbles and boulders. They are also overlain in places as on Bonanza creek, by a yellowish, loosely stratified deposit of flat pebbles derived mostly from the Klondike schists. The thickness of the white channel gravels, between Goldbottom and Last Chance creeks, ranges from 20 to 100 feet and the width from 500 to 2000 feet. Below Last Chance creek they have a thickness of over 100 feet and a width of nearly a mile.

On Paradise hill, below the mouth of Hester creek, the white channel gravels show some modifications. The lower gravels here, as shown in a couple of shafts, consist almost entirely of well-rolled quartz pebbles and boulders embedded in the usual white, fine-grained quartz sericite matrix. These quartz gravels are barren or nearly so, but are overlaid by auriferous beds consisting partly of schist and partly of quartz pebbles. The two gravels are distinctly different in character, and the abrupt passage from one to the other apparently indicates a break in deposition.

The high level river gravels are confined to the lower part of the valley where they overly the white channel gravels, on a small plateau separating Hunker creek from the Klondike above their junction. They also occur on the left limit resting on a rock-cut terrace.

Gold Contents of Gravels

Pay gravels occur along Hunker creek from claim No. 46 above Discovery on the right fork, down to the mouth of the valley, a distance of over twelve miles. A stretch of the creek about a mile in length, including Discovery claim and a few claims above and below it, proved very rich, the yield in places amounting to $1000 per running foot of valley. Another long stretch of almost continuously rich gravel extends from the mouth of Goldbottom down stream a distance of a mile and a half. Good pay has also been found at a number of points below this, notably on claim No. 71 below Discovery, and near the mouth of Henry gulch, on what is known as the Anderson concession. On claim No. 71 the gold has mostly sunk down into the bedrock, consisting here of broken andesite, and the overlying gravels are almost barren.

The white channel gravels have not proved so rich as on Bonanza creek, but a number of claims yielding good values have been worked for some distance above and below Goldbottom creek, on Paradise hill, below Hester creek, and on Last Chance creek and Dago gulch. On Paradise hill the gravels on bedrock are barren, and the gold occurs in an upper layer six to ten feet in thickness. The scarcity of water on the hill sides has seriously interfered with the working of the high level gravels of Hunker creek, and the greater part of the deposit is too low grade to bear the expense of pumping water for sluicing purposes.

Hunker creek gold occurs in bulky rounded grains along the upper narrow portion of the valley in the usual rough flattish grains and scales farther down. Nuggets are fairly numerous in the rich stretch near Discovery claim and also in some of the claims below Goldbottom. They are occasionally found as far down as Henry gulch. The gold from about claim No. 45 to No. 59 below is generally darkened on the surface by iron. The assay value of Hunker creek gold averages about $17.25 per ounce above Goldbottom, and from $16.50 to $17.00 per ounce for some distance below. On the Anderson concession, near the lower part of the valley, the grade is lower, some of it averaging less than $15.00 per ounce.

The two principal gold bearing tributaries of Hunker creek are Goldbottom and Last Chance creeks. Goldbottom creek is almost equal in size to the main stream at their confluence, and has a length of about six miles. It carries gold almost to its head, but the distribution of values is irregular and no very rich claims have been found. The best ground occurs near its mouth.

Last Chance creek, a stream about six miles in length, enters Hunker creek from the left near the lower end of its valley. It is gold-bearing up to the forks, a distance of four miles, and a number of the claims, especially in the first mile, have proved highly profitable. The white channel gravels follow the left limit up to No. 15 pup, a distance of two and a half miles, and are fairly rich in places. The gold obtained from the upper part of this occurrence is noted for its crystallized character. Last Chance gold is low grade, usually assaying from $14.50 to $15.00 per ounce.

Other tributaries of Hunker creek that have been worked to some extent are Mint gulch, Hester creek, Eighty pup, Henry and Dago gulches, on the left limit, and Hattie gulch on the right limit. With the exception of Mint gulch, the gold in these small gulches has mostly been derived from the white channel gravels.

Bear Creek

Bear creek empties into the Klondike two miles below Hunker creek. It is a much smaller and less important stream than Hunker and Bonanza creeks. It has a length, including Lindow creek, of about five miles, and occupies a narrow-bottomed box-shaped valley, which gradually narrows to a gulch towards its head. Bear creek has not proved particularly rich, although some good claims have been worked near its mouth, and moderate pay is found almost up to the head of Lindow creek. The gold is low grade, usually assaying less than $15.00 per ounce.

The plain of the old valley is conspicuous along the left limit of Bear creek up to Discovery pup. A small patch of the white channel gravels occurs opposite Discovery pup at a height of 350 feet above the present valley-bottom. The deposit here has a thickness of eighteen feet and is less compact than usual. It carries pay values in places.

Allgold Creek

Allgold creek heads with Dominion and Hunker creeks near the Dome, but flows in the opposite direction toward the flat creek depression and is the only creek draining the eastern and north-eastern slopes of the Klondike hills on which gold in paying quantities has so far been discovered. It was staked during the early days and a few holes were sunk to bedrock, but as no particularly rich spots were found, the claims were all, or nearly all, abandoned. They have been re-staked during the last two seasons and pay gravels have been found at a number of points. The longest pay stretch so far discovered occurs near the mouth of the creek, where several consecutive claims are being worked. The pay is light, none of the claims yielding much more than good wages.

The elevated white channel gravels occur in considerable volume on the left limit of Allgold creek, along the lower portion of the valley, and are overlaid, as usual, near the mouth of the creek, by rounded high level river gravels. They rest on a rock bench of varying width cut into the side of the valley at an elevation of from 150 to 250 feet above the present creek bottom, the elevation increasing down stream. The Allgold white channel gravels have not so far yielded gold in paying quantities, but practically no work has been done on them, owing to the scarcity of water for sluicing purposes.

Allgold creek gold is high grade, having an assay value of about $17.75 per ounce.

Gold-Bearing Streams Tributary to Indian River

Dominion Creek

Dominion creek is the largest and one of the most important of the gold-bearing creeks of this district. It heads with Hunker creek near the Dome, and flows at first in an easterly direction, but gradually bends round to the south and then to the west before uniting with Australia creek to form the Indian river. Its length, following the valley round its semi-circular course, is about thirty miles. The principal tributaries are Caribou, Portland, Laura, Hunter, Gold-run and Sulphur creeks from the right, and Lombard, Remington, Champion, Nevada, Jansen, Kentucky, and Rob Roy from the left.

Valley

Dominion creek valley heads in a steep amphitheatrical depression, very regular in form, cut into the divide between Dominion and

Hunker creeks. Lower down a deep narrow valley is developed, with steep slopes almost meeting below. Still further down, the bottom slowly widens out; small muck-covered flats, increasing gradually in width, border the winding stream, the grade diminishes and the slopes up to the high, bounding ridges become easier. In the lower part of Dominion creek the flats have an extraordinary width compared to the size of the stream. From Jansen creek to the mouth, they nearly everywhere exceed a third of a mile and, in places, spread out to half a mile or more. The stream itself, at the mouth, has a width of about twenty-five feet with an average depth, on the bars, of about a foot.

Terraces have been traced along the left limit of Dominion creek from Lombard creek to about two miles below Jansen creek. They also occur along the lower part of the valley, but at wider intervals. The terraces are low, seldom exceeding forty feet in height, and in some cases are less than ten feet above the valley-bottom. They are wider than the Bonanza terraces.

Dominion creek differs from Bonanza creek and other creeks extending along the Klondike in not possessing a well marked secondary valley. The present valley-bottom below Burnham creek is supposed to represent the elevated benches that border the Klondike streams. The reason for this is discussed in the description of the gravels.

Country Rocks

The rocks of Dominion creek have a greater variety than on the other creeks in the district. The upper part of the valley is cut through the grayish sericite schists of the Klondike series, alternating with bands of greenish chloritic schist. The latter is fairly massive in places, and is often filled with grains of pyrite and magnetite. In the central part of the creek, the Klondike schists are largely replaced by biotite-bearing schists, greenish schists and hard quartzose schists. Bands of dark graphite schists are also present, and limestones were found in the right bank opposite claim No. 123 below Discovery. These rocks resemble the schists on Indian river, and are referred to the Nasina series. The schists of the Klondike series come in again below Burnham creek, and are exposed down to a point midway between Gold-run and Sulphur creeks, where they are replaced by sheared granites, and these continue down to the mouth of the creek.

Gravels

The auriferous gravels of Dominion creek consist of yellowish creek gravels, white creek gravels underlying these, and terrace gravels.

The creek gravels are altogether of local origin and are formed from the rocks outcropping along the valley. They are similar to those in the valleys previously described. Between the two Discoveries, the country rock is unusually soft, and the pebbles are consequently small.

The thickness of the gravels and overlying muck varies along different portions of the creek. Between the two Discovery claims, the most productive part of the creek, the gravels range in thickness from two to seven feet, and the overlying muck and associated sediments from five to fifteen feet. Farther down near the mouth of Laura creek the thickness of muck and gravel increases to about forty feet. Between Laura and Sulphur creeks the depth to bedrock is usually between thirty-five and forty feet. Below Sulphur creek, the depth decreases again to about twenty-seven feet.

The yellow creek gravels, representing the present wash of Dominion creek, are underlaid between Burnham and Sulphur creeks and for some distance farther down by a white compact siliceous deposit, similar in every way to the high level white channel gravels of Bonanza and other Klondike creeks, and probably belonging to the same period. At first glance it appears strange to find these gravels on some creeks resting on high benches and in others underlying the present valley flats. The explanation is however simple. The elevated position of these gravels on Bonanza and Hunker creek is due, as stated before, to a recent general elevation of the country, which gave the streams increased grades and enabled them to cut deep, steep-sided secondary valleys in the floors of their old valleys. Both Bonanza and Hunker creeks empty directly into the master valleys of the district and were affected immediately by the deepening of these. Dominion creek, on the other hand, empties into Indian river many miles above the junction of the latter with the Yukon. Indian river is itself a comparatively small stream, and any increased cutting power which it acquired in common with the other streams, after the elevation of the country, has been expended in the lower portion of the valley and has not, so far, materially affected the upper portion. A secondary valley, in places narrowed to a canyon, is traceable from the mouth of Indian river up stream to a point above Quartz creek, where it merges with the older valley. The wide flats which bottom the valley of the main stream, and of the large tributaries like Dominion creek, above this point, correspond therefore in a general way to the old valleys of Bonanza and Hunker creeks, now represented by high benches, and not to the present valley-bottoms.

The white gravels on Dominion creek are comparatively thin, seldom exceeding fifteen feet in thickness, and in the lower portions of the valley, they occur, in places, as long, buried ridges running parallel to the general direction of the valley. The intervening spaces are filled with the loose, yellow wash of the present stream.

The low terraces bordering Dominion creek, above Burnham creek, indicate a slight deepening of the upper portion of the valley. The gravels on these terraces are similar to the creek gravels, except at a couple of points where they consist of angular fragments of bedrock massed confusedly together.

Gold has been found along the greater part of the whole length of the Dominion creek. The pay-streak begins about claim No. 22 above upper Discovery in the narrow gulch part of the valley, and has been followed, with some blank stretches, down almost to the mouth of the creek. The most productive part extends from Lombard creek down to lower Discovery and a couple of miles beyond. A yield of nearly half a million dollars worth of gold is reported from some of the richer claims in this portion. The schist bedrock on Dominion creek is softer and less open than on Bonanza creek, and the gold does not sink in it so readily. On this account an extraordinarily rich layer of gravel, a few inches in thickness, is often found immediately overlying bedrock.

Creek claims have been worked at a profit below Lower Discovery, although the pay streak is often interrupted by barren stretches, down nearly to Jansen creek, and bench claims for a couple of miles farther. No pay has been found below this, until the mouth of Gold-run creek is reached. A second rich stretch commences here and continues down to a point below Sulphur creek. Wide flats border this portion of the valley and persistent prospecting was required to discover the pay-streak. The gold occurs mostly in the underlying white gravels. The claims are not rich in the Eldorado meaning of the term, but carry sufficient values in most cases to enable them to be profitably worked. The pay-streak is reported to be 1,000 feet or more in width in places.

The terrace gravels on the left limit of Upper Dominion creek proved very rich, and some of the claims in the vicinity of Lower Discovery and up the valley to near Upper Discovery, have yielded large returns for the amount of work done. Bench claims are being worked at the present time on the left limit at intervals down to Creek Claim No. 149 below Lower Discovery.

The gold on Dominion creek presents the usual variety. Above Lombard creek, it occurs in rough rounded grains and small nuggets. Farther down, a mixture of heavy grains, some well-worn and others quite rough, with a more flaky variety, and an occasional large, well-worn nugget is found. Below Lower Discovery the gold becomes finer and more flaky and nuggets are only occasionally found. The gold on Lower Dominion below the mouth of Gold-run is coarser than on portions of Upper Dominion and was probably largely derived from Gold-run creek.

The bench or terrace gold often occurs in fairly large flat grains, more uniform in size, smoother, and more worn than the creek gold.

The assay value of Dominion creek gold increases slightly but steadily descending the valley. At Upper Discovery the average value is about $16.75 per ounce, at Lower Discovery $17.04, and at claim No. 133 below Lower Discovery $17.26. The gold from the claims below Gold-run is still higher in grade, averaging about $17.50 per ounce.

Gold has been found on very few of the numerous tributaries of Dominion creek. The streams entering it from the left are all barren, so far as known, and only three producers, Cariboo, Sulphur, and Gold-run creeks have been found on the right limit, and of these only the last two are important.

The creek gravels of Cariboo creek have yielded little or no gold, but some producing claims are being worked on a wide low bench situated on the left limit, about a mile above its mouth. This bench supports a bed of gravel ten to twelve feet in thickness, which has, in spots, proved moderately rich. The gold is coarse and rough.

Gold-Run Creek

Gold-run creek enters Dominion creek from the right, five miles above its mouth. It has a length of about eight miles and a course nearly parallel with Dominion creek above its southerly bed. It is a small stream, from six to eight feet wide at its mouth, but, except in very dry seasons, gives sufficient water for sluicing purposes.

The valley of Gold-run is a flat-bottomed depression more than a quarter of a mile wide near its mouth. The bordering ridges are uneven, and have a height of from 1,200 to 1,500 feet above the valley-bottom. Terraces occur on the left limit, near its junction with Dominion creek, and on the right limit, about three miles above its mouth, but no continuous system exists. The country rocks consist, in the few exposures seen, of the sericite and chlorite schists of the Klondike series.

The gravels on Gold-run, about claim No. 13 above its mouth, are similar to those on the creeks already described. They are rather more quartzose than usual and are also irregular in thickness, the muck occasionally sinking down almost to bedrock. The thickness of gravel and muck varies from twenty to over thirty feet. Below claim No. 13, the bedrock sinks suddenly, and the overlying gravels and muck increase from twenty-five to over fifty feet in thickness. The depression is filled with white siliceous gravels similar to those on Dominion creek. They continue down to the mouth of the valley and out into and down Dominion valley. The cause of the sudden sinking of the bedrock floor of Gold-run valley is not fully understood. It is possible that the line of shafts following the pay streak down the valley may pass at this point over the edge of a buried terrace, and that a more graded channel exists in other parts of the wide valley, but this could not be proved.

The productive part of Gold-run creek, like that of Eldorado creek, occurs near its mouth. The main pay-streak commences just above the mouth of No. 43 pup, and has a length of about three and a half miles. A few claims have been worked above No. 43 pup but the yield has been small. Below the mouth of this gulch, an almost continuous stretch of pay gravels has been worked down to, and out into, Dominion valley. Near the mouth, the pay occurs in the buried white gravels and, farther up, in the yellow creek gravels. The claims along the lower part of Gold-run creek, while not equal to those on Eldorado creek, proved exceedingly rich. A number of the best claims will probably yield considerably over a quarter of a million dollars worth of gold. The gold is generally rather coarse and angular, although a few smooth grains are occasionally intermixed. Nuggets are not plentiful and no very large ones have been found. The grade of the gold is high, the assay value averaging $17.65 per ounce.

Sulphur Creek

Sulphur creek heads in the Dome, and empties into Dominion creek, two and a half miles above Australia creek. It has a length of seventeen miles, measured along the valley. At its mouth, it is a stream of about twelve feet wide, with an average depth of about six inches, on the bars. In the productive part of the creek the water supply is much smaller, but, except near the head, one or more sluice heads are usually available. The principal tributaries are Green, Friday, Meadow and Brimstone gulches on the left, and Quinn and Black Diamond gulches on the right.

The valley of Sulphur creek is sunk from 1,000 to 1,500 feet below the crests of the bordering ridges. The slopes are easy and very uniform, and are somewhat steeper on the right limit than on the left. In the upper part, the valley is narrow and gulch-shaped, with a steep grade, but it gradually widens towards the mouth, and the inclination lessens. For some distance above the mouth, the grade scarcely exceeds twenty feet to the mile, measured by the aneroid. The increase in width is fairly uniform, but slight expansions and contractions occur at intervals all the way down. At the mouth of Green gulch, about five miles from the head of the valley, its bottom is 300 feet wide, and is cut by a narrow muck gorge thirty feet deep, in which the stream, here only about three feet in width, is confined. Seven miles farther down, the valley flat has a width of 750 feet, and near the mouth this increases to nearly a third of a mile. A general cross-section of the valley shows a flat of varying width bordering the stream, from the edges of which the surface rises gently to the bases of the main slopes of the valley; then, a sharp ascent of from 700 to 1,000 feet, followed by easier slopes to the crests of the bordering ridges. A marked peculiarity of Sulphur valley is the absence all along its course of well-defined terraces. Sulphur creek is singular in this respect, as, with the exception of Gold-run creek, where they are only feebly developed, gold-bearing terraces are prominent along all the productive creeks of the district.

A second peculiarity of the valley is the continuous rise, referred to above, between the edge of the flat bordering the creek, and the base of the hills, amounting in some parts to fifty feet or more. Bench claims have been staked along this rise, but, where shafts have been sunk through it, bedrock has been found at about the same level as near the creek, and the rising surface has been shown to be due to a great accumulation of muck. It is possible, however, that, in places, terraces may be buried below the muck so completely that no sign of them appears on the surface.

Bedrock

In the upper part of Sulphur creek and down to about claim No. 50, below Discovery, the rocks consist principally of the greenish and light greenish schists of the Klondike series, similar to those found on Upper Bonanza. The schists are cut by numerous quartz veins and by occasional bosses and dikes of quartz-porphyry. In the lower part of the valley, the schists become coarser, more granular, and appear to change gradually to a granite gneiss. Exposures are scarce along the valley, and the character of the rocks can only be ascertained from specimens obtained from shafts sunk to bedrock.

Gravels

The gravels on Sulphur creek are similar to those on Gold-run creek. The yellow creek gravels are underlaid, descending the valley, on claim No. 55 below, by white gravels, and these continue down to its mouth. The gravels are overlaid by an unusually heavy bed of muck. On claim No. 36 above, the muck has a thickness of fifty feet, and on most of the claims the depth to bedrock is between thirty and forty feet.

Gold Contents of Gravels

Pay gravels occur pretty continuously along Sulphur creek, from a point a short distance above the mouth of Green gulch down to claim No. 35 below, a distance of about seven miles. The claims along this stretch are seldom exceptionally rich, and a few are barren or nearly so, but most of them yield fair returns. Gold in paying quantities is found above Green gulch for a distance of three miles, but the pay-streak is interrupted by barren intervals. Some pay has been found in spots in the lower part of the creek. The white gravels are less productive on Sulphur creek than on Gold-run and Dominion creeks.

Sulphur creek gold is lower grade than Gold-run gold, averaging about $16.60 per ounce. It follows the general rule in occurring in large angular pieces in the upper gulch part of the creek, and in small, flaky rough grains farther down. With the exception of Green gulch, on which some gold has been found, none of the tributaries of Sulphur creek have been found productive.

Quartz Creek

Quartz creek heads in the Dome ridge, where so many of the Klondike streams originate, and flows southward to Indian river, which it joins seventeen miles below the mouth of Dominion creek. It is a short stream, about nine miles in length, but forks repeatedly along its course, and, with its numerous branches, has curved out the widest and most conspicuous basin in the district. The principal tributaries are Calder, Little Blanche, and Canyon creeks on the right, and Toronto and Mack's fork on the left.

The valleys of the main stream and of the larger tributaries are bottomed with the usual wide flats. They have been deepened, resembling the Klondike rather than the Upper Indian river streams in this respect, and portions of the old valley-bottom occur as wide benches along the right limit. The benches are everywhere low, and, in places, the ground covering has been removed. Quartz creek was the first creek in the district on which gold was discovered, but the production from the creek claims, up to the present time, has been comparatively insignificant. The leanness of the creek gravels is somewhat remarkable, as this stream cuts the Klondike schists (the gold-bearing rocks of the district), and with its tributaries has carried away and concentrated the metallic contents of an enormous amount of material.

A few creek claims are being worked at intervals from the mouth of the creek up to claim No. 18 above Redford's Discovery. At Redford's Discovery, the creek has been displaced over a hundred feet by the slow advance of a heavy bed of muck on the left bank. The pay gravels are overlaid by about seventy-five feet of muck, and are reached by inclines from the present creek channel. A number of the claims above and below Redford's Discovery have been worked at a profit.

The bench gravels on Quartz creek are more important than the creek gravels. A gravel-covered terrace follows the right limit from Canyon creek down to Calder creek and also extends for a short distance above and below these creeks. Below Canyon creek, the terrace is a third of a mile wide and 110 feet high, but decreases both in height and width, descending the valley. It is built principally of gravel, the underlying bedrock having an elevation of only a few feet above the present valley-bottom. The shafts to bedrock on the various claims vary in depth from 100 feet to sixty feet or less. Near Calder creek the pay-streak approaches the edge of the valley, and the deposit is worked by open cuts.

The Quartz creek bench gravels consist of compact grayish gravels below, and looser yellowish gravels above. They are darker in colour and less siliceous than the white channel gravels of Bonanza creek, but are very similar in other respects, and are referred to the same period. They are moderately rich, the pay occurring as usual in the lower few feet of the deposit, and a large number of claims are being worked.

The tributaries of Quartz creek are not important, although a few claims have been worked with success on Little Blanche and Canyon creeks.

Eureka Creek

Eureka creek flows into the Indian river from the south, five miles below Dominion creek. It is a small stream, about eight feet in width, where it enters Indian River valley, and about ten miles long. It divides, three miles above its mouth, into two nearly equal branches, both of which head in a range of high hills that border this part of Indian River valley on the south.

The valley of Eureka conforms to the general type of the district. In the lower part, the muck-covered flats bordering the stream are from 300 to 900 feet wide. A well-defined bench, fifty feet in height, occurs on the left limit opposite the forks, and continues up the creek for a couple of miles. At No. 4 above Discovery, the bench is ninety feet in height.

Country Rocks

The rocks on Eureka creek differ from those on the other gold-bearing creeks in the district. The Klondike series occur near its mouth but is soon replaced by the slates, quartzites and dark and green schists of the Nasina series, and these continue to the head of the stream. The discovery of gold in streams cutting these rocks is important, as they have a wide distribution throughout the territory.

Gravels

The Eureka stream-gravels consist, mainly, of imperfectly rounded pebbles of dark and green schists. Quartz pebbles and boulders, sometimes of large size, are also present, and granite occurs occasionally. In the upper part of the valley, the gravels, as usual, become coarse and angular. The creek gravels are from four to eight feet in thickness, and are overlain by from ten to twenty feet of muck. The terrace gravels consist of the same materials as the stream gravels, but are rounder and more worn. Quartz pebbles are also rather more abundant. Eureka creek is not a rich creek, but a number of claims have been worked at a profit, both in the main valley and on both forks. On the left fork, the pay-streak follows what is known as No. 18 pup, and up to the mouth of No. 13 pup continues up the latter for a few claims. The gold from the right fork is very coarse, and nuggets worth from twenty to fifty dollars are reported. The grade of the gold is low, averaging about $14.59 per ounce. The Eureka creek terrace gravels contain some gold, and a couple of claims are being worked on them.

Mining Methods in the Klondike

Creek claims are worked, with few exceptions, either by sinking and drifting, or by open-cut work. A description of these two methods is given by the writer in the Summary Report for 1900 and the following account is partly a repetition of that.

The greater part of the claims are worked by the first method. A shaft is sunk to bedrock, and the pay gravels around the foot of the shaft are thawed out and hoisted to the surface. If the work is done in the winter, the material is piled up in great dumps and sluiced in the early spring; if in the summer time, the two operations are carried on simultaneously. In the better-worked claims, a system of drifts is extended from the shaft or shafts to the edge of the claim, or of the pay, as the case may be. The drifts are connected by cross-cuts, and the farther blocks are worked first.

The gravels are everywhere frozen, and require to be thawed before they can be extracted. This was done in early days by wood fires, or by heating the water at the foot of the shafts with hot stones, but now, except in remote districts, is done altogether with steam thawers or pumps.

Thawing by steam is a simple operation. The steam is usually obtained from the boiler that furnishes power for hoisting and other mining operations. It is passed through rubber hose, to the ends of which pointed steel tubes, four or five feet in length, are attached. The latter are driven into the frozen gravel and steam is forced through them for a period of from six to twelve hours. They are then withdrawn and the thawed material is removed. The points require steam equal to about one horse power each, and thaw from one to three cubic yards of gravels at a shift. Any number can be used.

In thawing with water, a small Worthington pump with a three-inch discharge, and three quarters of an inch or inch nozzle is usually employed. Only a small amount of water is required, as the stream played against the gravel face is collected in a sump and used again repeatedly. The relative merit of steam and water thawing is still an open question among the miners. The size of the excavation can be more easily regulated with water, as the steam, especially in the summer time, heats the air in the chamber, and portions of the waste in the roofs thaws out and falls. Steam is used on the majority of the claims.

Timbering is seldom required, as the bed of frozen muck which overlies the gravels forms an extremely tenacious roof, and chambers of astonishing size can be excavated beneath it, in the winter time, without danger. In one case, on Dominion Creek, a muck roof, unsupported by pillars, covered a vault said to measure 140 feet by 230 feet, and remained unbroken until midsummer. Examples of muck roofs spanning vaults over 100 feet in width are common.

In working claims by the second method, that of open-cuts, the first object is to get rid of the muck covering. This is easily done in early spring by taking advantage of the spring floods and leading the water by several channels across the claim. The muck thaws easily and the streams soon cut down to the gravel, and then gradually widen their channels until they meet. In some cases, the process is hastened by blasting out the walls of the muck channel with slow explosives. When the muck covering is removed, the gravels usually thaw to bedrock in a single season. The upper portion, if barren, is removed and piled up where most convenient, and the underlying pay gravels are shovelled up or hoisted in buckets, and sluiced in the ordinary way. The open-cut method of mining leads to a more complete recovery of the gold, but is too expensive to be used where the barren overburden of muck and gravel exceeds ten to fifteen feet in thickness.

While the general system of mining creek claims has changed very little since the early days of the camp, there has been a great improvement in the plant employed. Wood fires, for thawing, as stated before, are now altogether superseded by steam thawers and pumps. The hand windlass has been replaced by steam hoists working with self-dumping buckets, and steam scrapers are used, instead of the shovel and wheel-barrow of early days, to remove the waste in open-cuts. On many of the claims the water for sluicing purposes, instead of being flumed from a point up the creek distant enough to give the required grade, is now pumped up, and the sluice boxes are placed high enough to carry the tailings where required. The employment of steam power and machinery, in place of hand labour, has reduced the ordinary expenses of mining by nearly one-half, and has given value to long stretches of gravel on the various creeks formerly too low grade to work.

The equipment required to work a creek placer claim at the present time by the drifting method, where the water for sluicing is pumped up, consists of a 35 to 50 H.P. boiler for furnishing power, a hoist and self-dumping bucket worked by an 8 to 10 H.P. engine, a centrifugal pump with a 6-inch discharge for elevating water for sluicing (driven by a 15 H.P. engine), and a small Worthington pump with three inch discharge, an inch nozzle for thawing or a set of points when the thawing is done by steam. The installation of the plant on one of the distant creeks usually cost from \$5,000 to \$7,000. The operating expenses on an ordinary claim, with one shift and night thawing, amount to about \$100.00 per day, and from 50 to 60 cubic yards of material are mined and sluiced daily.

On a few claims in the district, the mining methods are different from those described above. A dredge, originally intended for work on the bars of the Lewes river, has been operating on Bonanza creek for the last three seasons. The work done has shown that, where the gravels are completely thawed, they can be worked very cheaply by dredging, but where frost is encountered, thawing, as in the other methods, must be resorted to. In dredging, also, the bedrock is not seen, and there is always some uncertainty in regard to the completeness of the recovery of the gold. Where the bed-rock is hard and blocky, the gold often sinks down along the jointage and bedding plane to a depth of from three to five feet, and part of it must almost necessarily be left behind. In soft bedrock, it is probable that the recovery of the gold is nearly complete, as it does not sink so deep, and the material containing it is easily removed.

Steam shovels are being used on several claims in the district, and where the conditions are suitable they handle the gravels and certain kinds of beds cheaply and effectively. The overlying muck requires to be sluiced off in the usual way, and the gravels must be thawed out.

Another attempt, worth mentioning, at cheap mining on the creeks, introduces the hydraulicking principle, but is still only in the experimental stage. On the Gold-run creek, a couple of claims have been equipped with long China pumps and bucket elevators. The pump and gravel elevator, each about seventy feet in height, rest in a sump excavated twelve to fourteen feet deep in bedrock. The gravels are washed into the sump by a stream of water under a small pressure, and are carried up by the bucket elevator and dumped into the sluice boxes. The China pump elevates the water used in hydraulicking, and it serves again to wash the gravels. If this method proves successful, a number of other claims in Gold-run creek will be equipped in a similar manner.

The pay-streak in the elevated white channel gravel is worked from drifts along bedrock starting at the rim, or, when the deposit is wide, from the foot of the shafts, often over a hundred feet in depth, sunk to bedrock. A small amount of open-cut work is usually done along the rim.

The scarcity and, in places, almost complete absence of water has greatly hampered mining operations on the benches. In early days the pay gravels were largely washed in rockers or trammed down to the creeks, and sluiced there. Ditches have now been constructed to the heads of some of the creeks and gulches tributary to the main valleys. The supply from these is, however, usually small, and only available for a portion of the season.

Numerous attempts have been made to pump water up from the creeks to sluice the hill gravels, but in most cases, with indifferent success. The Electric Power Co. of Dawson is now operating several small pumping stations along the Bonanza creek, but the price charged, \$7 to \$8, per sluice-head per hour, is prohibitive, except on the richer claims.

A few hydraulic plants, some using water pumped up from the creeks, and others gravity water, have been installed at various points to work the hill gravels. The pumping plants have not proved successful in the past, but experiments in this direction are still being tried. The installation of the largest pumping plant in the district was commenced and nearly completed during the past season by the Pacific Coast Mining Co. The plant is situated at the mouth of Adams creek, and is intended to work a group of claims owned by the Company on Chechaco hill, originally one of the richest on Bonanza creek, but now largely drifted out. Two pumping engines will be employed when the plant is in full running order, the main one having a capacity of 3,000 gallons per minute against a head of 350 feet, and the auxiliary one of 1,500 gallons per minute. Power is furnished by two Cahall water-tube boilers, giving, together, 528 H.P. It is intended to force the water through two twelve-inch discharge pipes up to a reservoir on the hill 350 feet above the pumping station. This will give a head of 150 feet at the base of the gravel deposit, where the monitors will be stationed. This company has shown great enterprise in undertaking a costly scheme of this kind, and it is hoped that their operations will meet with success. A Riedler pumping engine, with a nominal capacity of 1,500 gallons per minute, was also installed during the past season, by Alex. McDonald, at the mouth of Dago gulch, on Hunker creek, for use on Dago gulch.

When the water used is obtained by gravity, hydraulicking operations have shown good results. The Anglo-Klondike Company, under the management of Mr. Coffey, have been operating successfully, for a couple of seasons, two small hydraulic plants, one on Fox gulch and the other above Boulder creek. The water is flumed and siphoned from a point on Boulder creek about three miles above its mouth. A supply of 200 inches is available for a few weeks in the spring and fall, and is delivered under a head of about 200 feet. In Mr. Coffey's report to his Company, in 1902, it is stated that in a run of twenty-two days 29,000 cubic yards were sluiced, and that the actual hydraulicking cost was under fifteen cents per yard. The total operating expenses, including cost of plant and cleaning bedrock, were thirty-five cents to the cubic yard, or $1.96 per square yard of bedrock. In the same report it is stated that the actual average cost of mining and sluicing by the ordinary drifting method amounted to $5.85 per square yard of surface. No allowance is apparently made in the statement for the original cost of the water-right and flume. This comparison in cost between the two methods is, however, scarcely fair to the latter, as the hydraulicking operations were carried on around the rim where the gravels are thin, and the tailings easily disposed of. When the deeper portions of the deposit are attacked the cost per square yard of surface will necessarily be greater. The increased cost may, however, be compensated for by the greater amount of gold recovered, as it is known that the gravels contain some values throughout.

The demonstration by Mr. Coffey of the feasibility of hydraulicking successfully the frozen hill gravels is important, but in the present circumstances can only be taken advantage of to a very limited extent, as the local supply of water is small and intermittent and only obtainable at a few points.

Origin of the Placer Gold

There is little doubt that the Klondike gold, or the greater part of it, at least, is detrital in origin, and has been largely derived from the auriferous quartz veins cutting the older schists and especially the igneous schists of the Klondike series. The veins are small and the number destroyed and concentrated as pebbles and boulders in the valley-bottoms is almost incalculable. The high level white channel gravels have a volume, on

Bonanza and Hunker creeks alone, of nearly 500,000,000 cubic yards, and nearly, if not quite, half the whole deposit consists of quartz grains, pebbles and boulders derived from veins. This figure, large as it is, represents only a fraction of the vein material destroyed, as the volume of the white channel gravels was originally at least a third, and possibly a half, greater and a further allowance must be made for the large percentage of quartz ground up and carried away. The total production of the Camp will probably approach $200,000,000; the average gold tenor of the quartz was not, therefore, large, and probably did not exceed a few cents to the ton.

The derivation of the placer gold from quartz veins, as pointed out by Spurr in regard to the Fortymile district, is evident from the character of the grains. The greater part of the gold occurs in irregular flattened discs and bulbs very similar, when unworn, to those in the veins. Many of the grains and most of the nuggets inclose quartz, and a few are themselves inclosed in quartz. Pebbles and boulders speck'd with gold are also occasionally found. A boulder from Bonanza creek, near Discovery, weighing sixty ounces, contained twenty ounces of gold. Additional evidence of the detrital origin of the gold is afforded by its worn character in the creeks, while the younger grains and nuggets found in the gulches are always rough and angular. The richest quartz, so far discovered, occurs near the head of Victoria gulch a tributary of Bonanza creek. The partially decomposed slide rock, which covers the surface of the hill side below the quartz outcroppings, contains colours of gold, and it is significant that Bonanza creek is rich below the mouth of Victoria gulch, and practically barren above. Victoria gulch is itself gold-bearing, and the gold obtained from near its head is sharply angular. It is not inferred from this that all the gold in Bonanza creek came from Victoria gulch, as none of the heavy gold has travelled far, and the valley was probably repeatedly enriched from veins along its course, and from the older gravels, but that some of it was so derived seems certain.

While the greater part of the placer gold has been derived from broken quartz veins, a small percentage may have been precipitated from water carrying gold in solution. A boulder was found on one of the workings on Miller Creek, the upper surface of which was partially covered with thin specks and scales of crystalline gold. The crystals were arranged in a dendritic manner. Some of them were firmly attached to the rock, and others separated easily from it. The angles of the crystals were sharp and showed no wear of any kind, while the boulder itself, an autoclastic quartz-mica schist, was well-rounded. The gold evidently did not belong to the rock originally, and the only explanation of its occurrence under the peculiar conditions stated seems to be that it was taken up by some solvent and re-deposited on the surface of the boulder. A number of thin specimens of nearly unworn crystalline gold, often dendritic in structure, have been found on Eldorado and other Klondike creeks, and they may have originated in this manner. The bulky, octahedral crystals (the common crystalline variety), were probably derived, like the nuggets, from veins. Several specimens of these, identical in character with those in the gravels, have been obtained from the Victoria gulch quartz.

Quartz Veins

Quartz veins are exceedingly abundant in the schists of the Klondike series, and also occur, but more sparingly, in the clastic Nasina schists, and in the Moosehide diabase. The veins, as a rule, are small and non-persistent, varying in size from mere threads up to masses of quartz one to two hundred feet in length and from four to six feet in width. Large veins occur occasionally, one on the Yukon river, below the mouth of Cariboo creek, measuring over thirty feet in width.

The common vein of the district is generally lenticular in outline, the lenticles, in the majority of cases, measuring only a few inches in width, and a few feet in length. The larger veins swell out, in places, to a width of from four to six feet, but are seldom traceable for any considerable distance. They follow the planes of schistosity, as a rule, or cut them at a small angle. In some instances, while the strikes of the vein and the enclosing schist nearly coincided, the dips proved to be in opposite directions. Branching veins are not uncommon, the branches often cutting directly across the schists.

Besides the common lenticular variety, what might be called sheeted veins occur conspicuously in some of the sections, interleaved with the foliæ of the schists. These veins are seldom more than three or four inches, and are usually less than half an inch, in thickness. They differ from the lenticular veins in their more uniform thickness, and in their strict conformity to the inclosing schists, even when the latter are sharply bent.

The quartz veins are usually milk white or light grayish in colour, and, when much weathered, have a granular appearance. They inclose fragments of schist similar to that in the walls, are distinctly crystalline and occasionally show lines of interlocking, flattened quartz crystals. A notable feature of the veins is the presence in them of occasional feldspar crystals indicating a relationship to the pegmatites. A few examples of typical pegmatite veins or dikes occur in the district, and, in one case, a coarse-grained pegmatite vein was observed to pass along its strike into a purely siliceous rock. The aqueo-igneous origin of the pegmatites, and their close genetic connection with certain classes of quartz veins, maintained by various writers, is supported by the facts observed in the Klondike district. In the neighbouring Fortymile district, Spurr has described a transition of similar quartz veins into pegmatites, and through the latter into aplites.

The lenticular quartz veins are much younger than the schists, and are older than the massive andesites and quartz porphyries. They were probably formed during, or, as a consequence of, the intrusion of the granite mass south of Indian river.

The metallic contents of the quartz veins present little variety. Iron is usually present in the form of pyrites and, less frequently, magnetite, often in sufficient quantities to give the vein a rusty colour when weathered. Copper pyrites and galena, the latter sometimes argentiferous, occur less frequently, and free gold has been found in a number of veins, occasionally in considerable quantities. A short lens of quartz found near the head of Victoria gulch was studded at one end with numerous grains and small nuggets of gold, some of them well crystallized. The gold occurred mostly at or near the surface, very little being found in the interior of the vein. Small veins carrying grains of gold have been discovered on nearly all the producing creeks.

Cassiterite (stream tin) has been obtained from the sluice boxes on Hunker, Bonanza and Sulphur creeks, but has not, so far, been found in veins. It occurs in smooth rounded or mammilated pebbles up to an inch in diameter. The presence of osmoridium with Klondike gold has also been detected by Mr. Carmichael of the Department of Mines, Victoria, B.C.

Lode Mining

Lode mining has, so far, made little progress in the Klondike district, although a great number of claims have been staked, and some development work has been done on a few of them. The veins, as already pointed out, are usually small and non-persistent, although they occasionally swell out into considerable lenses of quartz. They often give fair assays, and, in places, show free gold but, except in rare instances, are too small individually to make mines. They occur in great abundance and in some sections constitute a considerable proportion of the whole rock mass. The discovery of a zone of small auriferous quartz veins closely grouped and capable of being worked together is by no means impossible. The region is difficult to prospect, as the slopes of all the ridges are covered with a sheet of partially decomposed slide rock, blanketed in places with moss, and the valley bottoms are buried beneath muck. Bedrock is seldom exposed except along the summits of the ridges and the sides of the secondary valleys.

The most interesting group of quartz veins in the district is those referred to before as occurring near the head of Victoria gulch. The development work done on these consists of a few shallow shafts or pits, none of which reach any considerable depth, and a short tunnel. At one of the openings on the New Bonanza claim a short rich kidney of quartz, nearly six feet in width, was uncovered. A second opening, 200 feet to the southeast, has been sunk, following a smaller quartz vein in which no free gold could be detected with the naked eye, or an ordinary magnifying glass. A sample was assayed in the laboratory of the Survey and gave 2,625 ozs. of gold and 3,267 ozs. of silver to the ton. The silicified country rock, mostly sericite schists, adjoining the vein also proved to be auriferous. Other small quartz veins occur in the vicinity, all striking in a N.E. and S.W. direction. The coarse angular gold in Victoria gulch and No. 7 pup must have been obtained from these veins, or from neighbouring ones concealed beneath the surface covering, or wholly destroyed by erosion. Work on them is now temporarily stopped, but the prospects are certainly encouraging and warrant further investigation.

A claim in the Violet group, situated on the summit of the ridge separating Eldorado creek from Ophir creek, a tributary of Indian river, was worked during the past season, and is the only claim on which any considerable amount of development was done. The works consist of an open-cut about sixty feet in length, and a couple of shafts. The open-cut follows a quartz vein that swells out, in places, to a width of five or six feet. The vein is broken by several small faults, and follows, at one point, for a few feet, a cross-fracture plane, running at right angles to the general course. It strikes with the inclosing schists in a S.E. direction, but dips across them. A shaft is now being sunk a short distance north of the vein to intercept it in depth. The quartz is crystalline and, like many of the veins in the district, is dotted in places with reddish feldspars giving it a pegmatitic character. It holds a considerable amount of iron and, near the surface, weathers to a rusty colour. Some galena is also present. The gold values are variable, but are stated to average \$10.50 to \$11.00 per ton.

A large number of claims have been staked on Lepine creek, north of the Klondike river. The claims are staked on a wide band of sericite schist, the ordinary country rock of the district. The schist is often somewhat silicified and, in places, is impregnated with iron. Only one claim, the Great Eastern, was worked during the past season. This claim is situated south of the deep valley of Ruiter creek, a tributary of Lepine creek. The schists here are traversed by a wide dike belonging to the recent quartz-porphyry group, and both schists and dike rock are completely decomposed to a depth of at least fifteen feet. This decomposed material constitutes the ore. A tramway, half a mile in length, has been built, and the ore is trammed down to Ruiter creek, and treated in a small cyanide plant. The result of the season's operations is not known. Specimens of the ore, collected by the writer, and assayed in the laboratory of the Survey, showed only traces of gold.

The Tertiary rocks south of Indian river include large bands of conglomerates, some of which are auriferous, and numerous claims have been staked on them. Very little development work has, so far, been done. At the Britannia claim, situated on McKinnon creek, a few miles south of Indian river, a shaft sixty feet deep has been sunk, and a short tunnel has been driven into the side hill. The shaft penetrates through a peculiar, white, moderately hard conglomerate, discoloured in places with iron. The conglomerate consists mostly of small well-rolled pebbles of vein quartz imbedded in a siliceous matrix. Assays of several dollars to the ton are reported from this conglomerate and a mill test of two tons, at the government stamp-mill, at Dawson, gave $2.24 per ton. The gold is detrital, occurring in the matrix, and the deposit may be considered an ancient placer, probably of beach origin.

The conglomerates in the Tertiary basin are well worth investigating. They were brought down by streams traversing rocks, and by auriferous quartz veins; some gold must almost certainly have been deposited with them, especially near the mouths of the old valleys. Unfortunately, all traces of these have disappeared in the general erosion of the district, and a large amount of expensive exploratory work will be necessary to prove or disprove the existence of pay ore.

Present Condition and Future of Camp

The gold production of the Yukon Territory, since the discovery of the Klondike gold fields in 1896 is estimated by the statistical branch of this Department at over $96,000,000. The annual production has been as follows:

1896	$ 300,000
1897	2,500,000
1898	10,000,000
1899	16,000,000
1900	22,275,000
1901	18,000,000
1902	14,500,000
1903	12,500,000

The whole of this immense amount, with the exception of about $1,000,000 credited to the smaller camps, was obtained from the various Klondike creeks and benches and principally from the Bonanza, Eldorado, Hunker and Dominion creeks, and the Bonanza benches. The dwindling production since 1900, in spite of the increasing use of machinery is largely due to the gradual exhaustion of the phenomenally rich portions of Eldorado and Bonanza creeks, and of the richer Bonanza benches, and does not mark a corresponding decline in the mining industry of the region. The number of creek claims worked, and the amount of gravel handled, has increased, if anything, in recent years, and the decrease in production must be attributed to the lower grade of the gravels mined.

The centre of mining activity on the various creeks has moved steadily downward towards the wider and leaner gravel beds in the lower portions of the valleys but none of the principal creeks have been abandoned, nor will be for some years yet. Eldorado creek shows the effect of seven years work in an almost continuous line of dumps, from the mouth up to Gay gulch, but even in this rich creek some virgin ground still remains and many old claims are being, or will be, reworked. Claims completely drifted out have a value, on the richer portion of the creek, of from \$10,000 to \$15,000 each. None are being abandoned, as it is generally believed by the miners that the whole creek from Gay gulch downward will pay to be reworked.

Bonanza creek has been largely worked over from the head of the pay-streak at Victoria gulch down into the fifties below Discovery. A few claims and a number of partly worked claims still remain, and it is probable that portions of the valley will be reworked. In the lower part of the valley there are still considerable stretches of low and medium grade gravels practically untouched.

The Eldorado and Bonanza benches are rapidly approaching exhaustion, so far as ordinary placer mining is concerned. Very little drifting ground is now left on the rich hills above Adams creek. A considerable amount of work is still being done between Adams and Boulder creeks and also on Lovett and other gulches in the lower part of the valley.

The greater part of Hunker creek, above Goldbottom, has been worked over. A fair proportion of the claims below this point are unworked or only partially worked. Goldbottom, and Last Chance creeks, the two principal gold-bearing tributaries, also still possess considerable areas of unworked gravel. Good drifting ground has recently been discovered on the Hunker benches below Hester creek, and further discoveries are probable. The hill gravels are not so high grade as on Bonanza creek and have not been so fully prospected.

Dominion creek is in about the same condition as Hunker creek. The narrow, rich portion of the valley, above Lower Discovery, is largely exhausted, although a few claims are still working. Below Lower Discovery, the proportion of unworked ground rapidly increases. Dominion creek, except on a few benches, has not, up to the present, proved productive between Jansen and Gold-run creek. Discoveries of value in this stretch are possible. Numerous claims are being worked below Gold-run creek, and the large area of gravel already proved to contain moderate pay ensures continued mining activity here for some years.

The short rich pay-streak on Gold-run creek has been partially mined on every claim and, in places, is completely drifted out. Sulphur creek has not been worked so energetically as the richer creeks, and, in consequence, still possesses a considerable number of only partially worked, and unworked claims, and Eureka, Allgold, and Quartz creeks, all comparatively low grade creeks, are in a similar condition.

It will be seen, from this brief survey of the condition of the camp, that, while the richer portions of the principal creeks show signs of exhaustion, there still remain considerable stretches of unworked gravel, on all the producing creeks, rich enough to work under present conditions by ordinary placer methods. This industry, therefore, although it is bound to dwindle, will last for a number of years; exactly how long, it is impossible to say, but probably for a decade at least, even if no further important discoveries are made.

Placer mining in the future will, undoubtedly, be supplemented in the Klondike, sooner or later, by hydraulic mining on a large scale. The white channel gravels along Bonanza and Hunker creeks are ideally situated for work by this method, as they rest on comparatively narrow benches, at considerable elevations above the present valleys.

The volume of this deposit cannot be given precisely, but, from such measurements as were taken, is estimated at about 250,000,000 cubic yards on Bonanza and its tributaries, and at about 200,000,000 cubic yards on Hunker creek and its tributaries. About 15,000,000 cubic yards occur on a low bench on Quartz creek, and a smaller quantity on Bear creek. The Allgold creek occurrence of the deposit is extensive, but is lower grade than on the other creeks, and has not, so far, proved rich enough to drift.

While the principal values in the white channel gravels are obtained near bedrock, the deposit is auriferous throughout, and it is this fact that gives it such great importance. The cost of mining by the drifting method generally exceeds three dollars per cubic yard, and the proportion of the deposit rich enough to be profitably worked by this method measures less than half per cent of its total volume. The great bulk of the deposit, if worked at all, must therefore be exploited by a much cheaper method.

The small amount of hydraulicking already done has proved the existence of pay in the upper gravels, in places at least, and has also shown that, with a long exposed face, no great difficulty need be apprehended from the frozen condition of the deposit. The great drawback to hydraulicking is the absence of local water in sufficient quantities, and the necessity of bringing it, at great expense, from a distance, or pumping it up from the Klondike river.

Water Supply

The Klondike creeks are all small, and the available local supply of water is scarcely sufficient for sluicing purposes, and is quite inadequate under present conditions to furnish the amount required for hydraulicking on a large or even moderate scale. An additional water supply would benefit mining in the creek bottoms, but is chiefly required for the high level gravels, as, without it, only a small proportion of the great volume of these deposits can be worked at all.

The principal schemes proposed for augmenting the present supply include damming the valleys at certain points, and impounding the spring floods, pumping water from the Klondike, and bringing it by gravity from the Klondike and Twelve-Mile rivers or their tributaries.

The plan of damming the valleys, if successfully carried out, would add largely to the present supply, but it is doubtful if a sufficient volume needed for continuous hydraulicking on a large scale throughout the season could be obtained in this way. The valleys are all steep and comparatively narrow in their upper reaches, and high expensive dams would be required to impound any considerable quantity of water.

The establishment of a large pumping plant is only possible if water power be used, as the price of fuel for generating steam is prohibitive. The Klondike river could be used for this purpose. This stream has a fall of about fifteen feet to the mile, and a head of forty feet could easily be obtained in a distance of five miles. The flow, at ordinary summer level, averages about 80,000 miners' inches. Sufficient power could be obtained, by using the whole stream, to elevate about 2,000 miners' inches to the height required, to hydraulic the benches at Bonanza forks, and the plant, if necessary, could be duplicated higher up the river.

The installation of a gravity supply system is rendered difficult by the irregular topography of the country. The Klondike district, a high ridgy region, is separated from the surrounding country, except in the southeast corner, by wide valleys. It is bounded on the south by the valley of the Indian river, on the west by the Yukon, on the north by the Klondike, and on the east by the Flat Creek plain, a depression ten to fifteen miles in width, which extends from Stewart north-westward to the Klondike, and continues on past Twelve-Mile river. The Flat Creek plain separates the Klondike hills from the Ogilvie range (in which the streams it is proposed to tap originate), and must be crossed. It is underlaid by soft Tertiary deposits, is easily eroded, and, except at the summits, is trenched with great valleys, the bottoms of which are usually below the level at which water is required. The elevation of the plain, at the summit between the Klondike and Stewart rivers, is about 2,500 feet, and at the summit between Klondike and Twelve-Mile river, the first parallel stream at the north, is about 2,500 feet.

Schemes have been proposed for supplying the camp with water from the main Klondike or one of its upper southern tributaries, from Rock creek, one of its lower northern tributaries, and from Twelve-Mile river, the first large stream entering the Yukon, north of the Klondike.

The Klondike river, after issuing from the Ogilvie range, flows westward across the Flat Creek plain, and then skirts the Klondike hills to its junction with the Yukon at Dawson. The grade of the main valley up to Flat Creek, a distance of twenty-seven miles, averages about sixteen feet to the mile, and from Flat creek to the Ogilvie range is nearly the same, but increases after entering the mountains. Assuming the elevation of Dawson, at the mouth of the Klondike, to be 1,200 feet, water to hydraulic the hill gravels at the mouth of Hunker creek and Bonanza creek requires to be furnished at an elevation of 1,800 feet, and at Bonanza forks, 2,100 feet. To obtain this elevation with the water from the Upper Klondike, or its upper southern tributaries, the intake must necessarily be situated deep in the Ogilvie range, and the supply must be carried in pipes, flumes or ditches across a long stretch of broken mountainous country, and then siphoned across a part, at least, of the Flat creek depression before the border of the Klondike hills is reached. Afterwards, it could be led along the ridge separating the Klondike from Hunker creek until a favourable point be reached for piercing this ridge with a long tunnel. To supply Bonanza creek from the same source, many additional miles of piping and fluming, or a second long tunnel, would be necessary. The total length of a supply system from the upper Klondike cannot be given, as the contours of the Ogilvie range are only imperfectly known, but would probably approximate 100 miles, and inverted siphons would be necessary for a not inconsiderable portion of the whole distance. The feasibility of this plan seems doubtful on account of the great expense involved.

The Rock creek scheme, although also expensive, appears to present fewer difficulties. This stream enters into the Klondike from the north, four miles above the mouth of Hunker creek. Its grade is steep, amounting to 60 or 70 feet to the mile, and the necessary elevation is attained in about twenty miles, before the stream reaches the mountains, but above its forks. About thirty miles of piping, fluming and ditching and at least one long tunnel are required to bring the water from the intake to the northern bank of the Klondike valley opposite the mouth of Bonanza creek, and an inverted siphon, a mile and a half to two miles in length, would be necessary to bring it across the valley to a distributing point. The branch of Rock creek which it is proposed to divert is small, and cannot be depended upon to give a steady supply of more than 1,000 to 1,500 miners' inches. To obtain a larger supply it would be necessary to collect, by flumes or ditches, the water from its two other main branches. Water can also be turned into Rock creek above the proposed intake, from Spotted Fawn creek, a tributary of Twelve-Mile river, and also possibly from the north fork of the Klondike: 4,000 to 5,000 inches could be obtained from Rock creek and Spotted Fawn during low water and much more in the spring and fall. An additional supply, it is claimed, can also be obtained from the north fork of the Klondike.

Twelve-Mile river, like the Klondike, heads in the Ogilvie range, and crosses the northern continuation of the Flat creek depression on its way to the Yukon. Water can be obtained from the upper tributaries of this stream at a sufficient height to place it on the divide between Twelve-Mile and Klondike, from which point it would follow the same course as the Rock creek supply.

While it is possible, therefore, to obtain water for hydraulicking the Klondike gravels, both by pumping it up from the Klondike river and by gravity from streams flowing from the Ogilvie range, the installation of a large supply system flowing from 3,000 to 5,000 inches must necessarily be a costly undertaking and if, in addition to the high initial expense, the shortness of the working season be taken into consideration, it follows that cheap water, as it is understood in more southerly regions, can hardly be expected in the Klondike.

1904

Introductory Note

Dr. Robert Bell, Director, includes the following in his Summary Report for 1904* with reference to field work that year in the Yukon:

"Mr. R. G. McConnell, assisted by Mr. F. H. Maclaren was engaged in the new gold field of the Kluane district, westward of Whitehorse, in the Yukon territory. It embraces Alsek River, Kluane Lake and the north-eastern slope of the St. Elias Range. The copper deposits of the Whitehorse district were likewise further examined. Much topographical surveying in other parts of the region was accomplished by Mr. Maclaren.

"Mr. Joseph Keele investigated the recent discoveries of gold on the Stewart River and several of its branches, including Duncan Creek and vicinity. His labours embraced the examination of alluvial mining along several creeks."

THE KLUANE MINING DISTRICT

by R. G. McConnell

The Kluane mining district is situated along the north-eastern slopes of the St. Elias range, in the vicinity of Kluane lake, Yukon. It includes creeks such as Bullion creek and Burwash creek, draining the north-eastern slopes of this range, and also creeks such as Ruby and the Fourth of July which traverse and obtain their auriferous supplies from the bordering ranges on the north.

Indians reported the presence of gold, on streams tributary to the Alsek, early in the summer of 1903, and on July 4 of that year Discovery claim, on Fourth of July creek, was staked by Dawson Charlie, a well known Indian from Cariboo Crossing. Two days later Discovery claim on Ruby creek was staked by W. H. Weisdepp, and discoveries on other creeks in the vicinity quickly followed. In the same season coarse gold was found on a number of the smaller streams draining the north-eastern slopes of the St. Elias range. Bullion creek, a tributary of Slims river, was staked on September 28 by a party of miners consisting of Messrs. Altamose, Ater, Smith and Bones; members of the same party staked discoveries on Sheep creek, near the head of Kluane lake, in October, and on Burwash and Arch creeks in May, 1904. The former flows into the Kluane river a short distance below Kluane lake and the latter into the Donjek river. All the streams draining this portion of the St. Elias range are tributary to White river. Besides the streams mentioned, discoveries have been staked on Kimberley, Telluride, Canada, Vulcan and other streams of the St. Elias range, and on McKinley, Dixie, Marshall, Gladstone and other streams draining the Ruby range. The area of coarse gold discovery extends along the base of the St. Elias range for a distance of over seventy-five miles, and has a maximum width of about thirty miles.

The district is reached by wagon road from Whitehorse, the terminus of the Whitehorse railway. The road from Whitehorse follows a rolling plain bordering the left bank of the Lewes river to the crossing of the Takhini river, from which point a wide, continuous valley, occupied successively by the Takhini river, the Dezadeash river, Bear creek and Christmas creek, extends through the Kluane lake. Between Bear creek and Christmas creek

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* Ann. Rept., vol. XVI, p. ivA (1906).

a summit about 900 feet in height is crossed. The road from Whitehorse to Kluane lake has a total length of 143 miles. The Takhini river is navigable for light draught steamers, and the haulage of freight can be reduced about fifty miles by bringing it up this river on boats to Mendenhall landing, the point at which the road leaves it.

Previous explorations in the district are limited to the expedition of Messrs. W. J. Peters and A. H. Brooks of the U.S. Geological Survey in 1899 from Pyramid harbour by way of Kluane lake to Eagle city, on the Yukon, and the topographic work of Mr. J. J. McArthur, Department of the Interior, Canada, in 1900. A report on the principal features of the geology and topography of Mr. Brooks' route is published by him in the twenty-first annual report of the U.S. Geological Survey 1899-1900.

The district is varied in its topographic features; it includes a portion of the St. Elias range and extends north-eastward across the Shakwak valley into the flanking ridges and mountain groups.

The St. Elias range is exceedingly rugged in character. Viewed from the hills on the north it presents a complex of sharp, broken crest lines irregular in direction and rising in places into bold, rocky projections, some of which reach a height of over 10,000 feet above the sea. The numerous small streams which drain the northern slopes of the range in the vicinity of Kluane lake occupy deep, rock-walled valleys, scarcely wide enough in places to permit the passage of the streams. The larger drainage channels, on the other hand, such as Duke and Slims rivers, possess large valleys and are bordered by wide flats, which extend back into the range for many miles. The central part of the St. Elias range is covered with almost continuous snow fields, pierced in places by dark rocky points; smaller snow fields survive the summer on all the principal mountain groups and ridges. Glaciers occur at the heads of all the principal streams. The great Kaskawulsh glacier, the largest in the district visited, descends from the central nevé, and has a length of over twenty miles. Two large rivers issue close together from beneath this glacier, the Kaskawulsh, one of the main branches of the Alsek, and Slims river, one of the sources of the Yukon.

The country stretching northward and eastward from the St. Elias range is characterized by broad interlocking valleys enclosing mountain groups and ridges usually from 3,000 to 5,000 feet in height. The valleys are much older than the present drainage system. They have a width of from two to five miles or more, are flat-bottomed, and are floored with glacial deposits. The rivers which occupy them at present flow in narrow secondary valleys seldom excavated to sufficient depth to reach bedrock.

The great Shakwak valley at the foot of the St. Elias range is an important topographic feature. Its origin is unknown. It is now occupied by a number of different streams and lakes and is crossed transversely by the valley of the Dezadeash. Kluane lake, a large sheet of water forty miles long and three miles wide, with two arms, one twenty-seven miles in length, is situated in this depression. North-east of the upper end of Kluane lake are the Kluane hills, a worn ridge with an elevation of about 5,000 feet above the sea. These hills are bordered on the north by the wide valley of Upper Jarvis river, Kloo lake and Cultus creek, beyond which the country rises again into the Ruby range. Farther to the south a prominent elevated mass is enclosed by the Shakwak valley, Dezadeash lake and the great bow which the Dezadeash river makes to the east. The name Dezadeash mountain is proposed for these elevations. The summits of these mountains and the

Ruby range reach elevations of about 7,000 feet above the sea. They probably represent erosion remnants of an old low level plain, since elevated some thousands of feet and partly destroyed.

The drainage of the district flows partly north by way of White river to the Yukon and partly south by the Alsek to the Pacific. Dezadeash river heads in Dezadeash lake, and after making a great bend to the east, turns westward towards the St. Elias, and through it to the sea. It is joined, after entering the mountains, by the Kaskawulsh river, heading in the Kaskawulsh glacier, the two streams forming the Alsek river. Jarvis river, like the Dezadeash, also enters the St. Elias range from the lower region bordering it on the north. It is tributary to the Kaskawulsh river and drains the southern slopes of the Ruby range and a portion of the Kluane hills. The White river drainage system is represented by Slims river, the principal feeder of Kluane lake, and by a number of other smaller streams flowing from the north and south into Kluane lake and its outlet, Kluane river. Slims river heads in the same glacier as the Kaskawulsh river, and the two streams occupy portions of a wide continuous valley connecting the White river and Alsek drainage systems inside the mountains.

The Alsek river has twice been dammed in comparatively recent times, probably by the extension of glaciers across its valley, and long deep lakes were produced which extended far up the valleys of the Dezadeash and Kaskawulsh rivers. Fresh lake beaches, cut in loose talus slopes and still covered in places with drift wood, line the valley of the Dezadeash at the point where it enters the St. Elias range up to an elevation of 150 feet above the present water level; older, more worn beaches occur up to an elevation of 300 feet. The older beaches are covered with the ordinary forest growth of the region, and probably date back some hundreds of years, while the younger ones support only a few young spruces, seldom exceeding three inches in diameter, and groves of willows, small aspen and balsam poplar. The upper limit of the young beaches is plainly marked all along the valley of the Dezadeash, up to a point about midway between Marshall river and Canyon river, by this sudden change in the forest growth. Judging from the character of the beaches themselves, the undecayed driftwood, the young vegetation and the stories current among the Indians, it is probable that the lake which produced these beaches existed less than a hundred years ago.

The forest trees of the district consist only of the white and black spruces, the aspen, the balsam poplar and an occasional birch. As elsewhere in the Yukon territory, the white spruce is the most important tree. Considerable groves exist along the lower part of Slims river, on Kluane lake, on Silver creek and other places, but the district, as a whole, cannot be considered well wooded, and the supply of timber suitable for mining and building purposes is limited. The tree line in the St. Elias range has an altitude of about 4,200 feet above the sea, and the bordering ranges of about 4,700 feet. The upper portion of most of the auriferous streams rises above the timber-line and much difficulty is experienced in obtaining the fuel and lumber required.

General Geology

The district reported on includes two distinct geological provinces, namely, the St. Elias range and the flanking ridges and hills which border it on the north.

The country lying along the northern base of the St. Elias range is underlaid by a series of dark gray quartz-mica schists resembling in colour, composition and degree of alteration the argillaceous members of the Nasina series as developed along the Yukon river. These schists will be referred to as Kluane schists.

The Kluane schists outcrop over a considerable area; they occur all along the Kluane hills which border the northern shore of Kluane lake and they extend eastward across the valley of the Jarvis river and Kloo lake into the Ruby range. The eastern boundary of the formation crosses the Dezadeash valley at Aishihik river. The Kluane schists have not been followed south of the Dezadeash valley, but must extend a considerable distance in this direction as they cross the valley in a band fully twenty miles wide. They were traced northward to a point near the lower end of Kluane lake, where they are replaced by gray granites and green schists.

The wide Shakwak valley, at the base of the St. Elias range, is floored with gravel, and the junction between the Kluane schists and the rocks forming the St. Elias range was only seen in one section. North of the point at which Jarvis river enters the St. Elias range, micaceous schists, which are referred to the Kluane series, occur at the base of the range underlying less altered dark and green slaty rocks and schists. They were not found in the interior of the range either in place or in the wash of the streams, and it is doubtful if they outcrop again towards the southwest.

The general strike of the Kluane schists is W.N.W. and is approximately parallel to the direction of the St. Elias range. The strike is very regular except near intrusive masses. The dip of the schists, both in the Kluane hills and in the southern slope of the Ruby range is N.N.E. or away from the St. Elias range at angles of from 30° to 60°. Near the eastern limit the influence of a great granite mass east of Aishihik river is felt; the dips become steeper and, in places, the beds are overturned. The schists, in the single exposure found along the base of the St. Elias range, dips to the south under the range or in the opposite direction to the inclination of the beds in the Kluane hills, the first foot-hill range to the north. The intervening valley has probably been excavated along the crest of a wide anticline.

The Kluane schists consist almost entirely of a great series of well foliated quartz-mica schists, varying somewhat in colour and degree of alteration, but very homogeneous throughout. Like the Nasina series they are ancient clastics, partially and, in places, entirely, recrystallized. They differ from the Nasina series in the absence of quartzite and limestone bands. Mineralogically they consist essentially of lines and small lenticular areas of quartz and feldspar grains separated by curving lines of biotite and a white mica. A specimen from an exposure north of Jarvis river, where it enters the St. Elias range, contained, in addition to the usual minerals, numerous grains of glaucophane and epidote.

The Kluane schists, with the possible exception of a band of granite gneisses, which borders them on the north, are the oldest rocks in the district. They are pierced in several places by granite areas resembling the coast range granites, and probably belonging to the same period.

The geology of the small portion of the St. Elias range hurriedly examined during the past season is exceedingly complicated and is, as yet, imperfectly understood. The bedded rocks are broken at frequent intervals by intrusions of various kinds, and the sequence of the formations differed in all the valleys ascended. It was found possible to discriminate four great series of rocks, none of which are probably older than Upper Palæozoic.

North of Jarvis river the Kluane schists are overlaid at the foot of the range by several thousand feet of green schists interbanded with dark shaly beds. These are probably the oldest rocks in the portion of the range examined. They have a wide distribution, being found on the lower part of Kaskawulsh river, on Slims river, on Bullion creek, and along the foot of the range on Burwash creek and Duke river.

The green schists of this series differ greatly in the degree of alteration they have undergone. In a few places they are completely altered into glossy chloritic schists, while in many of the sections their fragmental origin is still evident in hand specimens.

The green schist series is overlaid by alternating bands of limestone, green schists and dark slaty rocks passing in places into a hard cherty variety. A few fragments of corals collected on Bullion creek indicate a carboniferous age for this group. The green schists of this series are similar in appearance to those in the underlying group. The limestone, when unaltered, occurs as a hard, dark, compact rock, but in most instances it has been partially or wholly recrystallized into a gray granular variety, and in extreme cases has been altered into a snow-white, even-grained marble. A wide band of limestone at the head of Sheep creek has been shattered and crushed into a rock difficult to distinguish from an agglomerate. The crushed limestone often carries iron, and, when weathered, displays bright red colours.

The mountains bordering the Dezadeash river, from the point where it enters the St. Elias range to its junction with the Kaskawulsh, a distance of seven miles, are built almost entirely of a great series of tufaceous beds which are probably younger than the schists of the preceding group. These beds form a definite group and will be referred to as the Dezadeash series. They have a thickness of fully 10,000 feet. They occur both in heavy beds, usually gray, and in thin alternating dark and grayish bands, the former hard, compact and occasionally cherty, the latter coarse, granular and soft. The lowest beds of the series occur along the base of the outer range, where they are altered into hard flags, and, in places, are almost schistose. The higher beds, except where pierced by a couple of intrusive masses, show only slight traces of alteration and are often soft and friable. The tuffs of the Dezadeash series are replaced, ascending the Kaskawulsh river, by green schists. The character of the contact was not ascertained.

The fourth subdivision of the rocks of the St. Elias range largely consists, like the preceding one, of beds of tufaceous origin, but include, gray sandstones, grits, conglomerates, dark shales and occasional lignite seams. Two areas of these rocks occur in the portion of the range examined, one on Kimberley and Telluride creeks, two tributaries of Jarvis river, and the other at the head of Sheep creek. The Sheep creek beds are less indurated than those on Kimberley creek, include a larger proportion of tuffs and occur in brightly coloured alternating green, red and brown bands.

The rocks of this group are very similar to the lignite-bearing beds in the vicinity of Dawson, which have been referred by Dr. Knowlton, of the United States Geological Survey, on the evidence of fossil plants, to the Eocene. They are strongly folded and have participated in the principal mountain-making movements which produced the range.

A great variety of massive igneous rocks occurs in the St. Elias range. The specimens collected have not yet been examined in detail, and only brief descriptions can be given here.

Granite

A small area of gray medium-grained granite cutting limestones and green schists occurs at the south end of Kluane lake. Large areas of granite must occur in the interior of the range, a large proportion of the material brought down by the Kaskawulsh glacier consisting of granite pebbles and boulders.

Diorite

Areas of diorite occur at the mouth of Vulcan creek, on the lower part of Bullion and Sheep creeks, on the Dezadeash river, and at the upper canyon on Burwash creek. Diorite pebbles were also found in the wash of a number of streams heading in high peaks which were not visited. The diorites vary from a quartz diorite consisting essentially of hornblende, biotite, labradorite, and quartz to a gabbroic or diabasic variety in which quartz is absent and the hornblende has the appearance of being derived from augite.

It is interesting to note that the Italian expedition which ascended Mt. St. Elias in 1897 under the direction of H.R.H. the Duc d'Abruzzi found the summit of the mountain to consist of diorite, and diorite probably occurs in many of the higher peaks of the range.

Pyroxenite

A large, coarse-grained, intrusive mass consisting mainly of augite and iron ore cuts the Dezadeash series of the St. Elias range on the Dezadeash river.

Diabase

This rock occurs at the canyon on Sheep creek and also at the head of Kluane lake.

Dunite

A small area of dunite was found on Burwash creek. The olivine of this rock is partly altered to serpentine.

Andesite

Andesites occur principally in connection with the lignite-bearing tertiary areas. A vesicular variety of this rock outcropping on Telluride creek was found to contain small quantities of bitumen.

Rhyolite

Light-coloured rhyolite rocks occur in small areas on Kimberley and Bullion creeks.

Effusive Volcanic Rocks

Large areas covered with successive sheets of lava of various kinds occur in the interior of the St. Elias range. The largest of these, in the district examined, commences near the junction of the Dezadeash and Kaskawulsh rivers, and extends southward for many miles. It has not been outlined, but must cover several hundred square miles. A second large area crosses Duke river valley near the upper forks.

The lava sheets are level or incline at low angles, and are evidently younger than the main mountain-making movements. They are, however, of considerable age, being traversed by wide valleys and having been worn into ridges and peaks closely resembling those in other portions of the range.

The varieties of the effusive rocks collected include dark diabases, gray andesites, white rhyolitic-looking rocks, and red, black and gray vesicular lavas. Indurated tuffs and agglomerates occur with the effusives.

Very little is known in regard to the structure of the St. Elias range. The general strike of the bedded rocks is nearly magnetic east and west, or parallel to the trend of the range. Local deviations from this direction, due to the numerous intrusive masses, are, however, frequent. The beds are steeply tilted, but are seldom, so far as observed, overturned or broken; they dip in both directions. No evidence of great over-thrust faulting, such as obtains in the Rocky Mountain range, was noticed. The effect of over-thrust faulting is to reverse the normal sequence of the beds and to place older formations above more recent ones. For instance, in the Rocky mountains the palæozoic limestones of the front ranges often rest on Cretaceous beds. In the St. Elias range, on the other hand, the bordering plains and ridges are underlaid by old schists, while the mountains are built of much younger rocks. It is noteworthy that, notwithstanding the strongly folded condition of the beds in the St. Elias range, the old Kluane schists are nowhere brought to the surface. It is possible that the upheaval of the range and the folding of the beds are due in large measure to the repeated invasions of the district by igneous rocks and not to great general earth movements due to compression, such as produced the Rockies. Normal faulting probably occurred along the base of the range.

All the lowlands of the districts reported on were buried beneath ice during the glacial period, but there is no evidence that the higher ranges were overridden. The ice poured down from the St. Elias range, the main gathering ground, through every opening in the outer ridges. It moved down northward-sloping valleys, like those of Bullion creek and Slims river, and up southward-sloping valleys, like those of Jarvis river and the Dezadeash. It flooded the great Shakwak valley at the foot of the range to a depth, in places, of probably 3,000 feet, and streamed eastward up the broad valley of the Dezadeash to the low Dezadeash-Tahkini divide, and then down the latter valley to the Lewes. Smaller streams flowed up the steep valleys, incising the southward slope of the Ruby range, and, in some instances, as at the head of Lake creek, crossed this range and descended into the valley of the Aishihik.

The Kluane hills, with an elevation of, approximately, 2,650 feet above Kluane lake, and 5,150 feet above the sea, were completely covered with ice, as shown by the presence of rounded foreign boulders and pebbles on the highest points. Ruby range was glaciated up to an elevation of about 5,200 feet above the sea. Below this point the contours are rounded and foreign drift material is always present. Above it the topographic angles are sharper and the slopes and summits are strewn with angular frost-riven fragments derived from the underlying schists.

The deep wide valleys traversing the region north of the St. Elias range are bottomed everywhere with glacial deposits, principally boulder-clays and silts, to a depth, in places, of several hundred feet. The boulder-clay is usually interbanded with stratified gravel beds. It is confined to the valley flats and bordering terraces, and does not occur on the summits and upper slopes of the ridges.

The boulder-clay is almost always overlaid by heavy beds of white silt and is occasionally interbanded with it. These white silts are precisely similar to the fine glacial material from the Kaskawulsh glacier now being carried away by Slims river and deposited in the upper end of Kluane lake and the lower sluggish part of the river; there is little doubt that they originated in the same way. Kluane lake will eventually, if the present conditions be maintained, become filled up and will be replaced by a silt plain similar to those bordering portions of the upper Lewes, the Macmillan, and most of the other rivers draining the glaciated highlands surrounding the Yukon plateau.

The glaciers of the St. Elias range are now receding, but not very rapidly. Undisturbed morainic groups occur in front of the Kaskawulsh glacier for a distance of at least half a mile, and long lateral moraines, heading in glaciers, border some of the tributaries of Telluride creek. Reasons have been given, on a previous page, for believing that a long lake lately covered the valley of the Dezadeash from a point below its junction with the Kaskawulsh nearly up to the Aishihik river. This lake must have been produced by an ice dam across the valley of the Alsek, and indicates a pronounced advance of the glaciers of the range less than a century ago.

Economic Geology

Placer gold has been found in the district in two groups of creeks, one heading in the outer ridges of the St. Elias range, and the other in the Ruby range, situated between Jarvis river and Aishihik river. Ruby creek, Fourth of July creek and McKinley creek are the most important creeks so far discovered in the latter group, and of these Ruby creek is the only one which has produced any considerable quantity of gold.

Ruby creek heads in the summit of Ruby range and flows southward, emptying into the Jarvis river after a course of about nine miles measured along the valley. It is a steep mountain stream with a large volume of water in spring and early summer, but gradually dwindling in size as the snows in the upper regions disappear, and in late summer the flow is reduced to a couple of hundred miners' inches or less. In its lower reaches Ruby creek has its course across the wide drift-filled valley of Jarvis river, and its valley is shallow and cut in boulder-clay. In the upper mountain portion it occupies a great narrow-bottomed depression from three to four thousand feet in depth cut out of the old schists of the Kluane series.

The valley of Ruby creek is floored in the lower part with boulder-clay and other drift deposits, and in the central portion with a shallow covering of stream gravels and boulders. In the upper portion the grade is so steep—in places exceeding 400 feet to the mile—that the gravel is often washed away and the bed-rock is exposed.

Mining on Ruby creek during the past season was practically confined to the central portion, extending from Claim No. 22 above Discovery to the mouth of Little Ruby creek at Claim No. 34 above Discovery, a distance of about three-quarters of a mile. The wash in this portion consists mainly of flat schist pebbles and angular slabs of the same material, with occasional large granite boulders often several feet in diameter, and a few quartz pebbles and boulders. It is shallow, seldom exceeding ten feet in depth on the claims now being worked, but is irregular in this respect, owing to the rough hummocky character of the bed-rock surface on which it rests. Some sluicing was done during the past season on most of the claims between

No. 28 above and No. 34 above, and on some of them pay was reported, but no particularly rich gravel was discovered, and the total yield did not exceed a few thousand dollars.

The gold, which is of local origin and is derived from the quartz veins cutting the Kluane schists, is coarse, rough and occasionally crystalline; it is more irregular in size than the Klondike gold, but nuggets have been found weighing nearly half an ounce.

The portion of Ruby creek at present being mined cannot produce any large quantity of gold; the body of gravels is small and has not proved high grade. Further down the valley the conditions are different, and it is possible that considerable bodies of workable gravels may exist under the boulder clay. Several attempts have been made to sink to bed-rock, but without success. Two shafts, one on Claim No. 15 above, and the other on Discovery Claim, have been sunk to depths of seventy feet and forty feet respectively, without reaching bed-rock. There is, of course, no certainty of finding gold under the boulder-clay, as the stream gravels may have been swept away during the glacial period, but the chances of important discoveries are favourable and seem to warrant the expense of a deep shaft. Drifts across the valley from the foot of the shaft would be necessary for a fair test, for it is unlikely that the present stream follows the exact course of the pre-glacial one. The valley is, however, narrow and the deviation cannot be great.

There is little chance of finding pay-gravels in the Ruby creek valley below the point at which the stream leaves the mountains, the present course of Ruby creek across the wide valley of Jarvis river being probably entirely different from the pre-glacial one.

Fourth of July creek is practically a continuation of Jarvis river. It is a much larger stream than Ruby creek, its flowage in early summer amounting to several thousand miners' inches, and it differs from the latter in dividing up, after entering the mountains, into several branches. It has cut a great valley back into the Ruby range much larger than the Ruby creek valley, and the various branches also occupy great rounded depressions sunk deep into the southern slope of the range.

The gravels in Fourth of July creek are similar to those in Ruby creek. The valley is floored with boulder-clay up to a point about three quarters of a mile below the mouth of Snyder creek, where it disappears. Farther up, the wash consists of coarse angular and sub-angular fragments of schist with some quartz and occasional boulders of granite. Above Snyder creek, the wash is shallow and bed-rock is often exposed. The proportion of quartz-pebbles and boulders in the wash is greater than in the Ruby creek gravels.

Fourth of July creek cuts the schists of the Kluane series through its entire course. The granite boulders were brought into the valley by ice, probably from the south, as the movement of the main ice sheet of the glacial period was northward, or up-stream.

Fourth of July creek and all its tributaries have been staked nearly to their heads, but so far very little effective prospecting work has been done. Colours of gold occur all along the creek: on Claim No. 62 above, encouraging prospects are reported from the surface gravels. On Claim No. 54 above, a shaft twenty-eight feet in depth has been sunk and pay-gravels are reported to have been found resting on boulder-clay. That so small an amount of work has been done is largely due to the excessive cost of mining in this remote region. Freight rates will probably be greatly reduced during the coming season and it is expected that the creek will receive a more thorough test. A deep shaft, to test the gravels under the boulder-clay in the lower part of the valley, but well inside the mountains, is desirable.

McKinley creek, like Ruby creek and Fourth of July, has been staked almost to its head, but very little prospecting has been done on it and no pay-gravels have been discovered. It is a large stream, about equal in size to Fourth of July creek; it enters Jarvis river a few miles above Kloo lake. A large tributary, known as Dixie creek, joins it a couple of miles above its mouth. McKinley creek occupies a wide, basin-shaped valley running for the greater part of its length parallel to the general trend of the Ruby range. Its grade in the longitudinal portion of the valley is low, but after bending to the south to join Jarvis river it falls rapidly, and, in places, has cut a small canyon in a granite area which it crosses.

Boulder-clay and other glacial deposits extend up McKinley creek for several miles. The depths to bed-rock along the greater portion of the valley must be considerable, and the great width of the valley will necessarily render prospecting for pre-glacial auriferous gravels a difficult and expensive undertaking.

Besides the streams mentioned, coarse gold has been found in the vicinity on Gladstone creek and some of its tributaries, on Marshall creek, a tributary of the Dezadeash, and on Printers creek, a small steep stream tributary to Cultus creek.

Auriferous Streams of the St. Elias Range

Nearly all the streams flowing from the St. Elias range, in the district examined, carry coarse gold. Considerable work, mostly of a prospecting character, was done during the past season on Bullion, Sheep, Burwash and Kimberley creeks.

Bullion creek is a typical St. Elias range stream. It heads in small glaciers at the summit of the range separating Slims river and Kluane lake from Duke river, and empties into Slims river after a course of about ten miles. It is a large, swift-flowing stream, very variable in its flow, but carrying under ordinary conditions about 2,000 miners' inches of water. Its grade is steep, averaging over 200 feet to the mile, and in flood it assumes a torrential character.

The valley of Bullion creek is a huge steep-sided gorge, narrow, but widening somewhat towards its mouth and bottomed with bare gravel flats. Midway in its course Bullion creek forces a passage for half a mile through a deep canyon so narrow that at a short distance it looks like a mere cleft in the rocks. This remarkable natural feature is due to a change in the course of the stream at the end of the glacial period. During that period the old valley was filled with boulder-clay and other glacial deposits to a depth of 1,000 feet. After the ice receded the stream began re-excavating its old channel and has succeeded in cutting through the glacial deposits, and in the lower part of the valley has also cut some distance into the bed-rock beneath. At the canyon the stream was forced to the north by the wash brought down by Metalline creek, which comes in at this point from the south, and in place of clearing out its old channel, as in other portions of the valley, it has sunk a new channel through limestone.

The rocks displayed along Bullion creek valley are exceedingly varied in character. They include green and dark schists, dark slates, gray limestones often weathering red and yellow, white marbles, diorites and a light coloured eruptive rock, probably a rhyolite. Bullion creek valley, as stated above, was filled with glacial wash during the glacial period to a depth of 1,000 feet. The stream has not succeeded in completely cleaning out its old valley, and narrow bands of boulder-clay and glacial gravels still cling to the steep slopes on both sides.

Bullion creek valley is bottomed all along, except in the canyon, with a layer of loose gravel, usually from six to ten feet in thickness. Near the mouth of the valley the depth to bed-rock is somewhat greater. The gravels are coarse and are intermingled with numerous granite boulders, some of huge size. No granite outcrops along the valley, and the boulders must, therefore, have been brought by ice from the interior of the range.

Claims on Bullion creek were being worked or prospected at the time of my visit at intervals from No. 31 above down into the fifties below. The discoverers of the creek are reported to have cleaned up forty ounces, mostly in very coarse gold, as the result of a few days work in some shallow ground at the foot of the canyon. The promise afforded by this find has not been borne out by subsequent experience on the creek. The gravels have been prospected at intervals all along the valley. They carry gold throughout, but have seldom, if ever, proved rich enough to pay wages under conditions at present prevailing in the camp. The distribution of the gold is very irregular. Bunches of gravel carrying good values occur on most of the claims prospected, but the general average yield is low, and seldom exceeds, according to the information obtained, \$3 to \$5 a day per shovel.

While very little pick and shovel dirt has so far been found on Bullion creek, it is probable that the gravels along the central part of the creek, at least, are rich enough to hydraulic. A company under the name of The Bullion Hydraulic Company was formed during the past season to take over most of the ground below the canyon and work it by this method. The conditions are favourable, on the whole, as the valley has a good grade and water is abundant, but some trouble will probably be experienced in removing the large boulders and in disposing of the tailings. The experiment is important, as, if successful, it will lead to similar undertakings on other creeks in the district.

The only prominent benches on Bullion creek are the narrow flats marking the upper limits of the boulder-clay. Some of the gravels with the boulder-clay are reported to be auriferous but have not been worked.

Bullion creek gold is coarse, and is worn much smoother than Ruby creek gold. It occurs mostly in flattened pellets, often of considerable bulk. Some fine gold is also present. Nuggets up to an ounce in weight have been found. The grade is high, averaging about \$18 per ounce. Copper nuggets are often found with the gold in the concentrates.

Sheep creek, in many respects, is a duplicate of Bullion creek, but is a smaller stream. It heads with Congdon creek, and follows a course nearly parallel with Bullion creek to its junction with Slims river. It is a steep creek, the grade exceeding 300 ft. to the mile. The lower part of the valley has the usual gorge-like character of the smaller valleys of the St. Elias range, and at one point contracts into a rocky canyon, but the upper part traverses an area of soft rocks and opens out into a considerable basin.

The rocks cut by the valley in its lower reaches are similar to those on

Bullion creek. In the upper part the valley enters a Tertiary area, and tufts, sandstones, shales, conglomerates and occasional lignite seams are exposed.

Very few claims were being worked on Sheep creek during the past season, and only one, No. 53 above, reported pay values.

Burwash creek is situated near the lower end of Kluane lake. It heads in the St. Elias range but has most of its course across an elevated plain which borders the range from Kluane lake to the Donjek river. It heads in glaciers, and in ordinary circumstances is a swift mountain stream from 15 to 20 ft. in width, but, like all glacial streams, its daily and seasonable flow is very variable, depending on the strength of the sun, and in times of flood it becomes a raging torrent. Its grade is less than that of Bullion creek, amounting in the central part of the valley to about 125 ft. per mile.

Burwash creek has cut a deep, trough-like depression in the lower part of the upland across which it flows, and in two places its valley contracts into narrow, rock-walled canyons difficult to penetrate except in low water.

The rocks outcroping along Burwash valley are extraordinarily varied. The varieties noticed, in a distance of about eight miles along the central portion of the valley, included bands of green, striped and dark schists, slates and shales, intruded at frequent intervals by diorite, andesite, rhyolite, diabase and dunite. In addition to these, a copper-stained amygdaloid occurs in the lower canyon. Quartz veins are rare, and few quartz pebbles occur in the wash.

Coarse gold occurs along Burwash creek from the foot of the lower canyon up stream for a distance of eight miles or more, but no very rich ground has so far been found. The miners were greatly hampered during the past season by the excessive cost of supplies, and most of them were obliged to stop work even before the short season ended. On this account very few, if any, claims were fully prospected, and on most of them only useless assessment work was done. Good prospects, and in some instances small amounts of gold, were obtained from several claims, and it is expected that considerable work will be done on the creek during the coming season. The gravels are shallow, are usually rather coarse, and contain numerous large boulders difficult to move. They are not frozen, and seepage water occasions considerable trouble.

A number of narrow, rock-cut benches supporting beds of gravel occur along Burwash valley at different heights above the creek, but usually low. The prospects from a number of these were considered very satisfactory, and, on several, pay gravels were reported and some mining was being done.

Burwash creek gold differs from that of Bullion creek in being much flatter. Most of the larger grains have been worn into smooth thin plates, and bulky nuggets are rare. The largest reported was valued at $3.

Some prospecting was done during the past season on Kimberley, Telluride and Canyon creeks. The last was not visited by the writer. Kimberley creek is a tributary of Jarvis river, from the south-east. It is a steep, swift, glacial stream bordered below with bare gravel flats, but inclosed in a narrow, steep-sided valley above. The gravels in the narrow part of the valley are shallow, loose and coarse. Gold to the value of $100 was reported to have been taken out of Claim No. 14 above as the result of a few days work. No work was being done on this claim at the time of my visit. Some work was in progress on the claim immediately below, but no pay gravels had been found. Good prospects were reported on Discovery claim and preparations were being made for sluicing. The result of the season's operations is not known. Telluride creek enters Jarvis river immediately opposite Kimberley creek, and is similar to it in general character. No mining has been done on this creek and very little prospecting.

The total production of gold in the Kluane mining district probably did not exceed $20,000 during the past season. The small production cannot be considered satisfactory, but it must be borne in mind that mining in the district is still in its initial stages, and that only a few claims in the whole district were worked during the past season, and these only for short periods. Also, while there was a considerable mining population in the district, most of the miners spent the summer, or a large part of it, in doing assessment work, most of it useless, on several claims, instead of fully testing one claim. Supplies could only be obtained in the district at prices prohibitive, so far as most of the miners were concerned; the freight rates alone from Whitehorse to Kluane lake amounted to thirty cents per pound, and to Burwash creek to over forty cents. Conditions during the coming summer will be more favourable; some of the claims are now roughly equipped and it is expected that, as a result of the construction of a government road into the district, freight rates to Kluane lake will be reduced to about ten cents a pound.

The discovery of coarse gold in so many creeks distributed over such a wide area is a fact of considerable importance even in the unlikely event of no large bodies of gravel rich enough to work by ordinary placer mining being found; portions of some of the creeks, at least, are certain, sooner or later, to be worked by more economical methods.

Other Minerals

Galena occurs in small quantities in the wash on Bullion creek, but was not found in place.

Native copper is found with the gold on Bullion, Sheep, Kimberley, Burwash and, in fact, on nearly all the creeks in this portion of the St. Elias range on which any mining has been done. It occurs in rounded nuggets and slabs, the largest seen weighing about a pound and a half, but is nowhere very abundant. A quartz pebble enclosing native copper was found on Bullion creek, indicating a vein origin for a portion at least of the mineral. No native copper has, so far, been found *in situ* in the district. Copperpyrite occurs in crushed zones on Telluride creek, impregnating a green, amygdaloidal rock in Burwash creek canyon and in small veins on Bullion creek. None of the occurrences seen are of commercial value. A belt of copper-bearing rocks appears to follow the St. Elias range northeast* to the International boundary and beyond. It has only been roughly prospected so far, but now that access to the region has become much easier will probably receive more attention.

The lignite-bearing beds on upper Sheep creek, referred to on a previous page, enclose several lignite seams, one of which measured over four feet in thickness. The lignite is of excellent quality and burns freely in an ordinary Yukon box stove. There is no wood along the upper portions of the creek, and lignite is used by the miners for fuel. Lignite also occurs on Kimberley creek, but is not well exposed.

* Should read 'northwest.'

THE DUNCAN CREEK MINING DISTRICT
(Stewart River, Yukon Territory)

by Joseph Keele

The earliest record of prospecting in the Duncan creek mining district is mentioned by Mr. Ogilvie in his report on the Yukon district. In the autumn of 1887 Mr. Ogilvie met and conversed with a miner who had spent the summer of that year prospecting and exploring on the Stewart river and some of its tributaries.

From the description of his travels this man, Alexander McDonald by name, appears to have ascended Mayo river to Mayo lake, afterwards going up Duncan and Lightning creeks. From the head of Lightning creek he crossed to the Ladue river, down which he floated on a raft for two days, but finding this stream flowing in a northeasterly direction and not south, toward the main branch of the Stewart as he expected, he abandoned the raft and returned to the point of his departure.

After prospecting for a time on the Gustavus mountains, he crossed to the McQuesten river and floated down that river to the Stewart.

McDonald gave the name to Mayo lake and river after Mr. Frank Mayo, one of the partners in the firm of Harper, McQuesten and Company.

In the summer of 1898 many hundreds of prospectors made their way up the Stewart. They were in search of the rich gold placers reported to exist in the vicinity of that river. For several years fine gold had been obtained in paying quantities on the bars of the lower Stewart, and in 1895 coarse gold was found on Haggart creek, a tributary of the McQuesten.

Some of the prospectors of 1898 reached the mouth of the McQuesten river, and a few of the more enterprising ascended that stream to the McQuesten lakes, prospecting on the small creeks as they advanced.

Among the latter were a party of three Swedes; these men appear to have been energetic prospectors. They located on the canyon on Duncan creek, about eight miles from the McQuesten river, after having satisfied themselves that this ground was the best in the neighbourhood. Here they built their cabins and erected a saw-mill, which was worked by water power, and for over two years worked undisturbed, making an occasional trip to Dawson for supplies. Being in such a remote and secluded position they never thought it necessary to stake their claims and record their discovery.

On September 12, 1901, a discovery was staked in the canyon on Duncan creek by a party of four prospectors. This discovery was staked during the absence of the Swedes and included the ground already worked by them.

Since the Klondike was made known this is the most important discovery made in the lower Yukon country.

During the year 1902 Duncan creek was staked from its headwaters to the Mayo river. Cabins were built on almost every claim and active preparations were made to develop the ground.

A good wagon road was constructed by the Government from the mouth of the Mayo river to Duncan creek, a distance of twenty-four miles. Road houses were established at several points and two rival town-sites were located at Mayo river and Gordon landing on the banks of the Stewart river.

A good deal of prospecting was carried on over the surrounding country, and in the spring of 1903 Minto creek was staked. During the autumn of the same year five discoveries were made on the smaller creeks flowing into Mayo lake. Highet creek, a tributary of Minto, was also staked about this time.

Previous Surveys

In 1898 Mr. J. J. McArthur, of the Dominion Topographical Survey, made a reconnaissance survey in this region. He mapped the upper portion of the Stewart river and part of the surrounding country*.

In the summer of 1900 Mr. R. G. McConnell made an examination of the Stewart river as far as Frazer falls**.

In 1903 Mr. A. J. McPherson, D.L.S., of the Dominion Surveys branch at Dawson, was instructed to take the necessary surveys for the purpose of establishing base lines on the various creeks already staked by miners in the district.

Mr. McPherson carried a chain and transit line from Dawson to the east end of Mayo lake by way of the White pass and Yukon winter road, and the Stewart and McQuesten rivers, to which he has connected the base lines of the creeks and by means of which he has fixed the position of the principal mountain peaks.

Geographical Position

The Duncan creek mining district includes the Stewart river and its tributaries from Mayo river eastward, the Mayo river and its tributaries, and the north and south branches of the McQuesten river and their tributaries.

The Stewart enters the Yukon river from the east at a distance of fifty-eight miles south of Dawson. The McQuesten and Mayo rivers are two of the principal tributaries of the Stewart. They enter the latter at distances of 100 miles and 170 miles respectively from the Yukon.

The district can be reached by steamboat from Dawson to either Mayo or Gordon landing, on the Stewart river, and thence by wagon road to Duncan creek or Mayo lake, or during winter with dog teams by way of Dominion creek to Clear creek, thence up the Stewart river on the ice.

General Description

The portion of the Duncan creek district here described lies east of the Tintina valley and west of the Rocky mountains. Its characteristics are well developed interlocking valley systems, which isolate small mountain groups, and areas of well dissected upland.

The Stewart river is the master stream of the area. It occupies a valley of mature erosion, the floor of which is a graded flat from two to three miles wide, but which attains a width of almost six miles at its junction with the Mayo and Talbot creek valleys. Innumerable small lakes and ponds are dotted all over these plains.

The next depression of importance is that occupied in turn by the Mayo river and Mayo lake, Rupe river, Ladue river and the south branch of the McQuesten. This valley is blocked with glacial debris in some places, and has a steeper grade than that of the Stewart river. The highest elevation of

* Report of the Department of the Interior, 1899.
** Geol. Surv., Canada, Summary Report, 1900.

the floor of this valley is on a wide undulating flat, from which the waters of the Ladue and McQuesten rivers divide. This valley is intersected by another and shorter valley lying north-west and south-east, occupied by Ross creek, some lakes at the head of Mud creek, Janet lake and Janet creek. Another very pronounced depression is that extending in an east and west direction from the Mayo valley to the McQuesten and occupied by Minto creek and lake and Bear creek. A branch of this valley extends in a south-westerly direction to the Stewart river and contains Moose creek.

Mayo lake is the largest sheet of water in the district. The main body of the lake is twenty miles long and from one and a half to two and a half miles wide, and lies in an east and west direction. A narrow arm of the lake, twelve miles long, extends to the southeast. The northern shores of the lake rise in gradual slopes to the Gustavus mountains. The shores to the south-east of the lake are abrupt and in places cliff-like, while those to the south-west are low and rise gently to ridges which are mostly below timber line.

Rupe river enters Mayo lake at its eastern extremity. It is a sluggish stream of about 150 feet wide and four or five feet deep. About one and a half miles from the lake it is joined by Edwards creek, a swift stream flowing from the south-west. The lower portion of Rupe river runs through a wide, flat-bottomed valley containing numerous lakes. Following this valley northward Ladue river can be reached by a portage of about seven miles from Rupe river. Ladue river flows in a north-easterly direction and enters the north branch of the Stewart river about 125 miles above Frazer falls.

Nelson creek enters Mayo lake at the extremity of the south-east arm. This stream is about seventy-five feet wide and two feet deep, and enters the lake without any perceptible current, but a few miles up the stream the current becomes swift.

The valley of the south arm of the lake extends up Nelson creek, gradually trending in an easterly direction. This valley also extends southward towards the Stewart river. Its bottom is a wide undulating flat, bordered by gravel terraces and contains a number of small lakes at various levels.

Most of the numerous streams that enter Mayo lake from the surrounding hills are short mountain torrents, throwing down considerable debris which they deposit in flabellate deltas extending into the lake. Mayo river, the outlet of the lake, at its western extremity, has cut through a wide gravel bench which previously formed a dam across the valley. This bench extends eastward along the lake shores as far as Keystone creek. Near the mouth of Edmonton creek are beaches raised in successive steps, the highest of which corresponds to the bench at the outlet.

The Mayo river, meandering through a wide valley, deeply floored with drift materials of various origin, has a fall of about ten feet to a mile. Wide benches rising to a height of 350 feet above the stream border the valley. They are continuous all along the eastern side and have diverted the waters of Janet lake from the Mayo river. About ten miles below Mayo lake, Field creek crosses the Mayo valley through a striking arrangement of eskars, kettle holes and mounds, and all the topographic characteristics of a terminal moraine. The material of the moraine is principally well-rounded pebbles, three to six inches in diameter. About two miles below Minto creek the Mayo river in the course of its meandering became superimposed on two rock-spurs projecting from the western slopes. The river has sawn a channel into the rock, thus forming canyons with walls 200 feet high and each about a mile long. The only other exposure of rim rock on the river occurs about a mile below Mayo lake.

The flow of water in the Mayo river was measured by Mr. Beaudette on June 20, 1903, and found to be 124,400 miners' inches (Californian).

The Gustavus mountain group is completely surrounded by wide valleys and forms a prominent topographic feature in the district. They are deeply dissected by streams which radiate from them in all directions. The head waters of the streams have worked back into the steeper slopes, leaving sharp edged ridges and peaks of a generally ruinous appearance. A deep ravine, cut down by Granite and Keystone creeks, divides them into smaller groups. Of the group overlooking Mayo lake, the highest point is Mount Albert, at 6,500 feet above sea level, while Mount Hinton, of the Duncan creek group, is the highest point of all, being about 7,000 feet above sea level. The northward facing slopes are, as a rule, precipitous. The slopes that face the south are less rugged and have easy grades. On the higher levels, in position sheltered from the sunshine, a good deal of snow remains throughout the summer. North-east of the Gustavus mountains, but separated from them by the wide valley of the Ladue river, rise the Davidson mountains, some of whose peaks are as high as Mount Hinton. This group is a spur from the Rocky mountains, whose higher peaks appear in the distance in continuous array, sweeping in a great curve towards the north-west. Twenty-two miles west of Mount Hinton and rising from the valley of the McQuesten, is Mount Haldane, a very prominent feature, visible from many points on account of the wide valleys which lead to and surround it. This mountain is known by the miners as Lookout. Its height is over 6,000 feet above sea level.

The upland areas bordering on the Stewart and Mayo valleys are composed of broad back ridges with curving profile breaking off more or less abruptly towards the valleys. These ridges have an altitude of from 3,500 to 5,000 feet above sea level, but small erosion remnants project from them to a much higher elevation.

General Geology

The rock bed of the gold placer diggings of the Duncan creek mining district is composed of an essentially schistose series, consisting partly of crushed eruptives and partly of rocks having a sedimentary origin. The schists derived from eruptives occupy the greater area, extending from Nelson creek at the south end of Mayo lake in a westerly direction to the McQuesten river. Their extension east and west of this area has not been determined. They outcrop on the Stewart river near Gordon landing and extend northward to upper Duncan creek and Haggart creek.

These rocks are principally derived from quartz porphyry and vary from a massive and only slightly deformed phase of this rock to a soft, foliated, sericite schist. The freshly fractured rock has a pale yellowish green colour, but becomes a reddish brown when exposed to weathering. The most abundant mineral present is quartz, and a typical schist is composed of thin parallel layers of quartz separated by films of mica, generally sericite. In many cases the quartz layers are not continuous, but are lens-shaped with thinly drawn out edges. Kidneys of quartz with blunt ends and wrapped with layers of mica-schist are also characteristic of large masses of the rock. These quartz kidneys vary in thickness from one to twelve inches and are arranged parallel to the general direction of foliation in the rock. On weathering a slaty cleavage is most in evidence, but in the massive varieties the jointing is more pronounced and the rock then breaks down in slabs and blocks. Rocks similar to these occur in the Klondike mining district. They are described by Mr. McConnell under the name of the Klondike series*. The Duncan creek rocks will probably be correlated with this series when the field work over the intervening area is completed. To the east of the south arm of Mayo lake, about half a mile from the shore, the rocks just described cut through a series of older rocks which are evidently of sedimentary origin. They now consist of massive and banded quartzite mica-schists and graphitic schists and extend across Mayo lake, forming the eastern portion of the Gustavus mountains and are the bed-rock in upper Duncan creek. In this last locality they contain banded crystalline limestones. These rocks have a marked resemblance to a series occurring on Indian river and elsewhere in the Klondike district, which are described by Mr. McConnell under the name of the Nasina series.

This older series are intruded by dark, green-coloured rocks which are mostly actinolite diorites, much decomposed. Around the heads of Ledge and Edmonton creeks these eruptives occur as dikes and stocks, protruding through the schist. They have a well-jointed structure and the surface blocks are all loosened from the mass. Similar eruptives are found invading the schists on the Gustavus mountains, on Lightning creek, on Haggart creek, and in the canyon on Mayo river.

Small masses of gray granite occur on Rupe river near Granite creek at the head of Dublin gulch, and on Rudolph gulch at the head of Highet creek.

Several dikes of biotite andesite cut through the schists in the vicinity of Bennett, Highet and McLaghan creeks. In the neighbourhood of Mayo lake the general strike of the schist is north-west with a dip to the south-west at an angle of 20 to 40 degrees. On Duncan creek the rocks are nearly horizontal. On Minto creek and its tributaries the strike is variable but has a prevailing direction to the north-east with a dip of from 10 to 40 degrees. In no case was a dip of more than 45 degrees from the horizontal observed.

Very little folding or warping of the rocks was noticed, but indications of normal faulting were occasionally seen.

There is sufficient evidence to show that during the glacial epoch an ice sheet of considerable thickness occupied all the valleys and submerged most of the intervening ridges. It is doubtful if even the highest peaks of the mountain groups were uncovered during the period of its maximum development.

The effect of the glacial action was first to widen the valleys and to disturb and transport the bulk of the loose material, then to generally disarrange the pre-existing drainage system and to profoundly affect the economic conditions. Scarcely any remnants of ancient high level river gravels remain. These have been shifted to lower levels and redistributed along the main valleys. Portions of former river and creek channels of lower level are often concealed beneath the great thickness of this material, and irregularities in bed-rock are frequently due to the gouging action of the ice sheet.

The glacial drift deposits consist of boulder clay, gravels, sand, silt and

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* Preliminary Report of the Klondike Gold Fields: R. G. McConnell, B.A.

clays. Their distribution is irregular, and varying conditions have affected their arrangement.

Description of Creeks

Duncan creek is economically the most important stream in the district. A great deal of development work was done on this creek, and from it was taken the greater part of the gold which the district has produced.

The head waters of this creek have their source among the highest peaks of the Gustavus mountains. These small streams on assembling form upper Duncan creek which flows through a wide valley in a north-westerly direction for a distance of four miles. It passes out of this valley through a narrow canyon and then enters the main valley of Duncan creek where it is joined by Lightning creek. It then runs in a south-westerly direction for nine miles and empties into the Mayo river at a distance of five miles from Mayo lake. Two important tributaries, Parent creek from the east, and Williams creek from the west, enter Duncan creek about five miles from its mouth. The fall from Lightning to Parent creek is about 250 feet, and from Parent creek to the Mayo river the fall is about 450 feet.

The flow of water in Duncan creek, as given by Mr. Beaudette's measurements on June 20, 1903, was 18,250 miners' inches. This was during the stage of high water.

The lower portion of the creek cuts through heavy deposits of gravel, sand and clay, and remnants of benches of these materials still cling to the hillsides to a height of 300 feet above the stream. In the neighbourhood of Williams and Parent creeks these deposits disappear from the valley bottom, and low rock terraces, covered with a thin coating of rolled gravels, are exposed. Above Parent creek the valley is wide and has a deep covering of drift on the bottom. About a mile below Lightning creek the valley becomes contracted and rock benches are exposed for about two miles up stream. The main valley continues in a north-westerly direction to the McQuesten and is occupied by the lower part of Lightning creek and by Christal creek.

About 500 yards from the mouth of Lightning creek upper Duncan creek issues from a narrow canyon. This canyon is nearly one mile long, with an average width of twenty-five feet on the bottom, and walls about 120 feet high. The canyon walls contract towards the lower end, and an almost vertical fall of eighteen feet occurs. The total fall through the canyon is about 350 feet.

The drift deposits which clog the valley of Duncan creek are principally of glacial origin. The frost does not strike down to such great depths here as it does in the Klondike district, so that the lower unfrozen layers of the glacial material afford constant passages for underground water.

The readjustment of the stream during the withdrawal of the ice from the valley is probably the cause of the canyon on upper Duncan creek, the stream being superimposed on a rock bench, through which it has since cut out its channel. The former channel appears to have been on the left limit and to have entered lower Duncan creek above Forty creek. It is now concealed by a thick deposit of gravels and clays. The old creek channel is not uncovered by the present stream at any point, except possibly at the low rock barrier which crosses the valley near Parent creek.

The channel at claims Nos. 124 and 125 below Discovery is new, being cut into a rock bench. The old channel is probably on the right limit, and is now deeply covered by gravels.

The discovery of coarse gold was first made in the canyon in the year 1898. The original discoverers worked secretly and never recorded their claims, but are said to have taken out not less than $30,000 during the three succeeding years. In the summer of 1903, the year of greatest activity on the creek, the sum of $30,000 was produced from the canyon claims, and in 1904 the amount produced was $15,000.

The canyon bottom above the falls is now all worked out, as is also a pot hole immediately below the fall. The pot hole, which is about twenty feet in depth, was mined at a considerable loss, no gold being on bedrock and very little in the gravels.

The conditions under which pot holes are formed are unfavourable for an accumulation of gold. The grinding action, consequent on the churning and rotary movements of the loose material brought over by the waterfall, tends to wear away and remove the metallic contents which may happen to be detained in the pot hole for any length of time.

The gold in the canyon lies on the bedrock, which is slightly folded and without much dip. Hard bands of quartzite, six to ten inches thick, alternate with soft schists, so that natural riffles are provided in which the gold is accumulated. Lying on bedrock are from one to three feet of boulderets, slates and coarse gravel. Large sized boulders are frequent toward the upper end of the canyon.

The gold occurs in flattened and rolled particles without quartz, and is evidently the finer portion transported from a pay-streak up stream. The assay value is $16.58 per ounce. About $28 to the shovel per day was the average result on the canyon claims.

A portion of the gravels on the lower benches at the upper end of the canyon has been washed down. These gravels do not contain much gold, but pay is found in the hollows of the underlying rim rock sufficient to afford fair wages. Above the canyon the creek bottom is about fifty feet wide. No proper attempt has been made to locate the pay streak on this ground.

At claim No. 17 above Discovery, or about a quarter of a mile above the canyon, shallow ground with good pay is being worked. Judging by the work done on adjacent ground and by the nature of the surroundings, it appears that the stream at this point is flowing across a rock bench. Overlying the bedrock on this claim are from three to twelve feet of boulders and coarse gravel, with a matrix of blue clay. The gold is found imbedded in the clay, a little above bedrock. It is very coarse, nuggets about the size of Lima beans being often found. The largest piece obtained was found this summer, and was worth $67.50. The nuggets were all worn smooth, and contained no quartz.

Above this point the valley widens out considerably and is floored with a great thickness of gravels and blue clays. Several shafts have been sunk to depths of from 60 to 120 feet without reaching bedrock.

The only result of the difficult and expensive exploitation of lower Duncan creek during the year 1903 was to demonstrate the impossibility of one individual miner working his 250-foot claim. The difficulties met with were mainly the deep mantle of drift which lies on the valley, and the underground water. Many of the shafts were sunk to a depth of over 100 feet, and 130 feet was reached on No. 104 below Discovery without getting to bedrock. The depth alone would not have deterred the miners from further sinking, but in every case they were forced to abandon their shaft on account of the heavy water encountered when certain layers of unfrozen gravels were pierced.

During the summer of 1903 Claims Nos. 53 and 54 below Discovery were grouped. A shaft sunk on 53 at some distance from the creek on the left limit reached bed rock at a depth of ninety-eight feet. In the winter drifting was continued toward the creek, the rock bottom yielding gold in small quantities. The water entering the drift during the progress of the work was got rid of by pumping, but the flow increased beyond the capacity of the pump, and the miners were forced to abandon the drift just as good pay was struck. The total amount cleaned up was $1,200.

On Claim 105 below Discovery good pay was obtained on the left limit quite near the creek at a depth of sixteen feet below the surface of a gravel bench. The gold rested in a layer of gravel overlying boulder clay. On the same claim another shaft reached the outer edge of a concealed rock terrace at a depth of forty feet. While drifting from this shaft toward the stream a pay-streak was found in the deeper gravels beyond the rock rim. This was a paying proposition, but had to be abandoned on account of water, no pumps being available. At Claim 124 below Discovery the creek flows between steep rock benches for about the length of four claims. The creek bottom is wide and has a layer of three to twelve feet of small boulders and gravels on the bed rock. The miners have confined the creek to the side of the valley by means of a head dam and trench and a bed rock drain two claims long has been constructed. The bed rock is a soft micaceous schist, dipping against the stream at an angle of about 30°. A sufficient area of bed rock has been cleaned up to prove it of very little value, and the undertaking has been unprofitable.

These are the only instances in which gold has been produced on the main creek, and although the value of the ground on bed rock has not been determined, many of the miners who failed on the creek still retain their confidence in it.

The owners of almost all the claims continued to do the annual assessment work necessary to hold the ground, either with the hope of selling out or finding someone to install machinery to test the creek.

The cost of placing the necessary machinery on the ground in such a remote district would be too great an initial expense for the individual holding only a 250-foot claim, especially as the richness of the ground is an unsettled question. A company which could acquire from one to two miles of the creek bottom at a reasonable price would be working on a different basis. One pumping plant of sufficient capacity to dispose of the underground water, or a well timbered bedrock drain, would serve for the whole workings. Diligent prospecting might reveal benches carrying good pay both on rim rock and in the overlying gravels, which, after the creek bottom had been worked out, could be mined by the hydraulic method.

Lightning creek carries more water than upper Duncan creek. It heads in the northern slopes of the Gustavus mountains, and flows through what appears to be a continuation of the main Duncan valley. About one mile from its mouth it emerges from a box canyon, somewhat similar to that on Duncan creek. Above the canyon, the creek bottom widens out to a broad flat bordered with high gravel terraces.

In pre-glacial times Lightning creek evidently discharged into the McQuesten river by way of Christal creek. The gravels on the right limit of the creek above the canyon occupy the old channel and contain very little clay. Some of the Lightning creek water still finds its way through them, and, rising to the surface near Christal lake, flows down Christal creek.

The canyon on Lightning creek is difficult to work on account of the great flow of water and the immense blocks of rock which have fallen from the walls. The bedrock is composed of banded quartzite and quartz-sericite schists shelving with a slight dip across the stream. Its attitude and the nature of its surface is generally unfavourable as a receptacle for gold.

Several shafts have been sunk in the creek bottom both above and below the canyon but without result, work being suspended in every case on account of water.

Claims were staked on Forty pup, Williams and Parent creeks. Some development work was done, but no gold was produced.

Parent creek has cut a recent channel through a rock bench bordering on Duncan creek, and has formed a short canyon nearly 100 feet deep. The bedrock of this canyon has not been tested, although it appears to be under shallow ground. The old channel of Parent creek probably entered Duncan creek about half a mile further up stream than the present one. A shaft has been sunk in the gravels over this old channel, but as it was found to be too deeply buried the work was abandoned.

The rock bench, which rises to about 100 feet above Parent and Duncan creeks, is covered with a layer of gravels with well-rounded pebbles, mixed with clays and sands. They have a rough stratification on top, which suggests former flood plain deposits. These gravels have been tested by several open cuts made through them to bedrock. No definite information regarding the gold tenor of the gravels could be obtained, the owners being absent, except in the case of one property where the prospects were said to be good enough for hydraulic operations.

Ledge creek enters the southeast arm of Mayo lake on the east side at a distance of four miles from the end of the arm. About three-quarters of a mile from the lake the stream emerges with a low fall from a narrow rock gorge. Above the gorge the stream flows through a narrow canyon for a distance of about half a mile. Beyond this point the valley widens out, but still presents a gorge-like aspect. Rim rock is seldom visible on this portion of the stream, being hidden by the loose material which slides at intervals from the hillsides.

Discovery claim is situated immediately above the gorge and occupies the greater portion of the canyon. The bedrock consists of dark-coloured quartz, mica-schist and graphitic schist, with numerous inclusions of quartz. From six to twelve feet of loose, unfrozen material rest on bedrock. This material consists of boulders of diorite from the heads of the stream, fragments of schist, gravels and clay. The gold has sunk in loose bedrock to a depth of about one foot. It is all coarse, the general run being about the size of dried peas, while nuggets weighing an ounce or more are frequently found. Most of the pellets of gold are coated with hydrated peroxide of iron, which gives them a dark brown colour. This incrustation on the gold is probably due to the decomposition of iron pyrites, small cubes of which are abundant in the bedrock. The assay value of the gold is $16.95 an ounce.

Four men worked during fifty-five days on Discovery claim this summer, their average production being $25 a day each.

Two claims above and two claims below Discovery were also worked this year with good results.

This constitutes practically all the productive ground on the creek.

Above and below this portion the depth to bedrock is too great to allow the ground to be worked by open cuts, and underground water interferes with drifting.

As the creek bottom is narrow, there is often great difficulty in obtaining space on which to pile boulders when opening drains and cleaning up bedrock.

Gold in paying quantities is said to be found on some of the benches. These benches can easily be worked after the creek bottom is exhausted of its pay.

The creek has a steep grade, and the heavy rainfall ensures plenty of water for sluicing all through the season.

Cascade creek, which enters the south arm of Mayo lake about two miles south of Ledge creek, is a small mountain torrent descending by a series of rapids through a narrow rock-gorge. The creek bottom is littered with large blocks of rock, which have fallen from the walls of the gorge. The material lying on bedrock is composed of well-rounded boulders of diorite and quartzite, fragments of schists and gravels.

Discovery claim is situated about half a mile from the lake. Work was begun on this claim and a small quantity of gold was obtained, but freshets, resulting from the heavy rains during last July, interfered with mining operations.

Steep creek enters the south arm of Mayo lake about eight miles from its southern end. It heads in a cirque carved out of the highest portion of the ridge bordering the lake on the west. The productive portion of the creek occupies a deep channel cut through rock-waste and glacial drift containing a good deal of clay. During low water in summer the stream is occupied in removing the material which is constantly creeping down the steep slopes. In time of flood the bottom is scoured out to bedrock in places.

The bedrock is a compact quartz-sericite schist, weathered to a light brown colour. The dip is down stream at an angle of about 40°. This attitude of the bedrock with regard to the stream is preferred by the miners, because once the gold becomes deposited water action cannot remove it except by actually eroding down the rock. Glaciated boulders from various sources, gravels and sands, and a stiff yellowish clay overlie the bedrock.

Four men were working last July on claim No. 2 above Discovery. Bedrock was easily accessible, but as it scarcely yielded wages the claim was abandoned. The gold from Steep creek is in small bright coloured particles of great purity. The assay value was $19.57 an ounce. A large quantity of black sand accompanies the gold.

Edmonton creek heads in northward-facing slopes of the same rugged uplands as Ledge creek, but drains the larger area. It enters Mayo lake about two miles from the eastern end. The principal country rock on the creek is a dark-coloured quartzite schist without marked slaty cleavage. Several diorite dikes cutting the schists are also eroded by this stream. The creek bottom is floored with a mass of well rounded boulders and angular blocks of diorite, accompanied by the usual gravel and clays.

During the early part of the summer four men worked on Discovery claim. Operations were commenced by thawing and washing down a frozen gravel bank which overlaid a low rock-bench beside the stream. This work was abandoned in favour of drifting, the latter being more economical. A bedrock drain was also commenced and other preparations made for next summer's work. The prospects were said to be encouraging.

Keystone creek is the largest of this group of small creeks. It heads in the Gustavus mountains and enters Mayo lake about five miles from the outlet. The lower portion of the creek occupies a deep and fairly well developed valley without the gorge-like aspect which characterizes those just described. Rim rock is rarely exposed along the stream. The valley bottom is floored with a thick deposit of boulders and gravels, and considerable loose material clings to the slopes above the creek, near which a few shafts have been put down. Bedrock was not reached in any of the shafts, as the underground water interfered with a continuation of the work. It is doubtful if this creek can be worked by the open-cut method. The benches above the stream are easy of access and may yield good results, but they have not been prospected. The fall of the stream is five feet in 100. No gold was produced on this creek.

Haggart creek is one of the principal tributaries of the McQuesten river. It enters the south fork of the latter at a distance of eighty-five miles from the Stewart river. It heads in high ridges near the north fork of the McQuesten, and occupies a very large winding valley with a flat floor. During 1898 several miners worked claims on Haggart creek, and are said to have sunk twelve shafts to bedrock. From some layers of the gravel good pay was obtained, but very little gold was found on the bedrock itself. Underground water caused considerable trouble. Work in this creek is now abandoned.

The bedrock on Haggart creek is principally a dark-coloured, quartz-mica schist. A diorite dike, cutting the schists, crosses the creek a short distance above Discovery. A highly altered and well mineralized dike, the nature of which has not been determined, also crosses the creek at the mouth of Dublin gulch, north of which the country rock is a white bedded quartzite, apparently of later origin than the schists to the south. These quartzites continue northward to the north fork of the McQuesten. No gold is found in the streams which cross these quartzites.

Dublin gulch, a small tributary of Haggart creek, enters on the left limit about twelve miles from the McQuesten. Work has been carried on here every year since 1898, but only two men were working here during the past summer. They were engaged on Claim 15 above Discovery. The work consisted of washing out the gravels in the valley bottom by means of a small hydraulic plant.

The surface gravels are here composed of small granite boulders and angular schist fragments with fine gravels. This is recent stream-wash, and carried fine colours of gold. The depth of this deposit is about six feet. Beneath this surface deposit lie two or three feet of blue clays with angular pebbles, under which is a seam of about a foot thick of fine yellow gravels carrying gold. Below the gravels are from two to three feet of yellowish gravels and clay, evidently of glacial origin, which contain small particles of gold. These glacial clays rest on old creek gravels. No bedrock has been exposed. A trench about 200 feet long and 40 feet wide, cut down to the old stream gravels, has been worked out. The yield was small, amounting to about the wages of the country, which are $7 or $8 a day.

The gold on Dublin gulch is fine and of a bright colour. The particles are of a wiry form or in small scales. It is accompanied by a quantity of heavy white sand, consisting of rounded grains of scheelite (tungstate of lime), from which it is difficult to separate the gold. There is also a run of flour-gold which is not saved in the sluice-boxes. It is possible that hydraulic mining could be successfully operated on this stream by a company acquiring a concession to cover the whole creek. There is a large body of the deposits, both on the benches and in the creek bottom. The boulders being generally small, not many of them would require breaking. The creek has a fall of five to eight feet in 100, but the supply of water is scarcely adequate for hydraulic operations on a large scale.

Highet creek is one of a group of creeks which drain the deeply dissected upland lying between the Mayo and the McQuesten valleys. The headwaters of the creeks on opposing slopes have cut back deeply on the watershed, leaving residual domes, the highest of which stand about 5,500 feet above sea level. The southward-facing slopes of this upland overlook a wide depression containing Minto creek and lake, also the heads of Bear and Moose creeks. The streams issue from narrow gaps in these slopes and flow across the bottom of the depression to Minto creek, which stream enters the Mayo river about ten miles from the Stewart.

Highet creek flows in a southeasterly direction and joins Minto creek about two and a half miles below the lake, its entire length being about seven miles. At two miles from Minto creek the stream issues from a short canyon, the bottom of which is strewn with large blocks of rock fallen from the crumbling and receding walls that rise on both sides to a height of about 250 feet. Above the canyon the creek flows through a narrow valley bordered by clay and gravel terraces which conceal the rim rock on which they rest. The headwaters of the creek are two small mountain-torrents, each carrying about a sluice-head of water. The one on the left limit is known as Rudolph gulch. The total fall from this point to Minto creek, a distance of five and a half miles, is 900 feet.

Considerable deposits of drift material adhere to the slopes above Highet creek to a height of 400 feet. These deposits consist of glacial clays and gravels, slide material due to the disintegration of the underlying bedrock and sands and silt. Masses of this material slide at intervals into the creek bottom. The bedrock is mostly composed of a sericite schist resulting from quartz porphyry. The rock is very compact in places and has a well-developed cleavage.

On the upper part of the creek several andesite dikes cut the schists. A small mass of granite has been exposed by erosion at the head of Rudolph gulch. Massive quartz-porphyry, only slightly deformed, occurs on the west side of the creek above the canyon.

Although Highet creek was prospected during several seasons and a number of shafts were sunk in the creek bottom, it did not produce gold in paying quantities until this summer. Late in the autumn of 1903 coarse gold was discovered on a rock bench opposite the mouth of Rudolph gulch. No discovery was allowed, on account of the proximity of the ground to discovery on Minto creek. The claims number from the mouth of the creek up, none of them being more than 250 feet long.

Work was carried on during the summer of 1904 on the benches on the right limit of four claims between 98 and 110. The lower edges of these benches are from one to twelve feet above the creek. The bedrock has a hummocky surface which rises with a slight incline toward the hillside. The upper edges have not been uncovered.

The gravels of the benches immediately above bedrock consist of well-rounded boulders of diorite, quartzite, granite and andesite, and slabs of schist with rounded edges.

Fine gravels and sand mixed with a stiff yellow clay fill the interstices between the larger fragments. Above these gravels is a layer of sandy clay in which fragments of schist from the country rock are embedded. These loose schist fragments have a parallel arrangement probably due to the slow creeping movement with which they descended the hillside.

On Claim 105, situated opposite the mouth of Rudolph gulch, a portion of the bench to a distance of seventy feet from the creek and about eighty feet long was worked out last summer. The inner face of the gravels was about twelve feet high. Water for sluicing was carried in a flume from a point a short distance up Rudolph gulch.

As the gravels are frozen, stripping and ground sluicing are done as far as possible in advance of the mining so as to allow thawing action to go on. Fires are built against the gravel faces as the mining progresses.

On beginning sluicing operations the tailings are allowed to go into the creek bottom. When enough ground has been cleaned up the tailings are piled on the bench.

Mining will be carried on by drifting on bedrock when the deposits toward the upper edges of the benches become too steep.

The gravels for a few feet above bedrock contain gold, but the principal source is from the bedrock crevices. The gold is of a rich, bright colour, the particles as a rule being water worn and smooth, but many of them are angular and wiry and are found adhering to fragments of schist or quartz. The yield of the benches averages about one dollar to the square foot of bedrock.

The loose material which occupies the creek bottom is an unsorted mass of deposits similar to those on the benches. Attempts to reach bedrock in the creek bottom have not been successful, on account of underground water.

A shaft which reached bedrock at a depth of twenty feet below the creek was sunk some years ago on Claim 66. Gold in paying quantities is said to have been taken from this shaft, but underground water prevented further working. Above this point some of the claims are being grouped, and it is said that an effort will be made next season to work the creek bottom by means of a bedrock drain.

The owner of Claim 56 has a small pump on the ground and intends to sink a number of prospecting shafts across the creek during the winter.

Discovery claim on Minto creek is situated about one mile below the lake. The valley is comparatively narrow at this locality and a few exposures of rim rock occur. The creek is about twelve feet wide and flows with a sluggish current through this portion of the valley. Gravel terraces, at various levels to a height of 350 feet, border the valley. Layers of fine silt and sand occur on all the terraces, overlying an unsorted mass of rounded pebbles, fine gravels, sand and clay. The pay ground on Discovery claim consists of the flood plains adjoining the creek. These flood plains or bars, about 1,100 feet wide, have been tested to a depth of about eight feet and found to yield from three to five cents to the pan. Sluicing was done on a portion of the claim last summer, the water supply being taken from McIntyre creek, a small stream on the left limit, carrying about a sluice head of water.

The great difficulty in working this ground is to secure a sufficient head of water and enough fall for the disposal of tailings, the elevation of the bars being only ten to fifteen feet above the creek.

While this property could not be worked by the hydraulic method, it seems to be an excellent dredging proposition. The gold occurs principally as small, bright-coloured scales, and appears to be due to the concentration of the surrounding benches.

Good prospects are also obtained on the lower gravel benches which border the lake.

Some shafts have been sunk in the wide valley of Minto creek below Discovery, but failed to reach bedrock. A soft blue mud, which rose in the shaft, was struck at one point at a depth of about 100 feet. All this creek, except the Discovery group of claims, is abandoned.

Some work was done on Eight creek and Jarvis creek, two small streams on the left limit above Discovery. These streams cut through the high gravel terraces and have concentrated a small supply of gold from them, but not enough to pay wages.

Johnson creek, which heads with Highet, flows in the opposite direction into McQuesten river. This stream was prospected during 1898-9. Several shafts were sunk in the creek bottom, but the usual underground water was encountered and the work was abandoned. It is the intention of some of the miners from Highet to test the benches on this creek during the winter.

The workable portions of Ledge, Cascade and Steep creeks and the canyon on Duncan are all shallow diggings. The mining is carried on in the primitive manner and with the implements usual to remote and partly developed placer districts. Only the richest and most available ground is worked and the gold is not all saved. The method of mining is as follows:

After ground-sluicing all the upper loose material to within a foot or so of bedrock, a timber dam, three or four feet high is built, across the creek at the upper end of the claim. A board flume, large enough to carry all the water in the creek, is fitted into the dam. This flume is generally about 200 feet long, but the length depends on the fall of the creek and the depth to bedrock. After the dam and flume are completed, an open cut which serves as a bedrock drain, is made in the creek bottom. This drain is started at such a distance below that its grade will strike bedrock at the lower end of the flume. After ample drainage has been secured for the bedrock, a line of sluice-boxes, connecting with the flume for the water supply, is placed in position. The boxes are fitted with pole-riffles to save the gold, and a grade of eight inches is allowed to each box.

Shovelling into the sluice-boxes is begun a little above the lower end of the flume, and a clearing is made on bedrock on which the tailings are piled. When the clearing is large enough to allow good drainage, it becomes no longer necessary to handle the tailings.

The large boulders are piled along the edge of the stream, those that are too large to handle being broken with sledge hammers or by fire.

Loose fragments of bedrock are put through the sluice-boxes and the solid portions are carefully scraped. The boxes are generally cleaned up every three or four days.

The total amount of gold produced by the Duncan creek mining district during 1904 was estimated at $32,000. Of this amount, upper Duncan creek contributed $15,000, Highet creek $10,000, and Ledge creek $7,000.

The gold was practically all produced on nine claims, and represents the work of about thirty men during sixty days. The season was unusually shortened owing to a late spring, heavy and persistent rain in summer and hard frosts which occurred early in September.

The total population of miners in the district in 1904 was about eighty. The greater number of these were engaged in doing assessment work on various creeks.

The sluice-boxes on every creek in the district catch grains and pebbles of hematite; they are exceedingly smooth, of a dark brown colour, and many of the pebbles have fragments of red jaspilite adhering to them. Hematite also occurs as a brown sand, from which the gold has to be separated by 'blowing'.

The miners are apt to apply the name 'tinstone' to any dark, heavy and smooth pebbles found in the residues, and that name has been erroneously applied to the hematite pebbles throughout the Duncan creek district.

Native bismuth in small rounded and flattened nuggets is of common occurrence with the gold on Highet creek.

Scheelite in small water-worn nodules of yellowish colour is caught in quantity in the sluice-boxes on Highet creek. The white sand which so often accompanies the gold on Dublin gulch is composed of rounded grains of this mineral.

Zinc-blende, with which is associated a small quantity of copper pyrites, occurs at Discovery claim on Duncan creek. This ore is exposed on the canyon wall below the falls, and occupies a vertical fracture in the schists. The ore body is about two feet wide and contains traces of gold.

A deposit of stibnite occurs on a small stream flowing into the Stewart river, about five miles above Gordon landing. The ore, which is associated with quartz, is deposited in the fractures of a thrust fault in the schists.

Only a small amount of ore is exposed. It contains gold to the value of $1.40 per ton.

An important quartz ledge occurs between the heads of two small streams, known as Twenty pup and Forty pup, which flow into Dublin gulch, a tributary of Haggart creek.

This quartz ledge outcrops on a sloping hillside about 500 feet below a mass of granite, and can be traced along the surface for a distance of 600 feet.

The granite and the quartz-lead both cut the country rock, which is a quartz-mica schist, with a strike north-east and a dip toward the west, or down hill, at an angle of about 40°.

An open cut, eight feet deep at the upper end, has been made on the surface, exposing the ledge for a width of twelve feet. The extreme width of the ledge is unknown.

The ledge or lead is composed of a number of vertical stringers of quartz, two to four inches wide. Between these stringers are portions of the country rock.

The quartz is impregnated with arsenical pyrites, is much weathered, and portions of its surface have a granular or pitted appearance. Its prevailing colour is green, due to a thin coating of a hydrous-arsenate of ferric iron. Occasional small specks of free gold, which appear to have weathered out from the pyrites, are visible. About 100 feet below the vein, a tunnel has been driven about forty-five feet into the hillside, with the intention of tapping the lead, but is still in the country rock. An assay, from samples taken over about six feet of the vein exposed in the open cut, was made by Mr. Connor, of the Geological Survey, and gave gold to the value of $10 to the ton.

In addition to the claim known as the 'North Star', on which the above work was done, eight other claims have been staked on the supposed extension of the ledge.

Several quartz veins occur at the head of Highet creek and on Rudolph gulch. Some of them contain no gold, but a sample from one vein, which carried a little arsenopyrite, yielded gold to the value of $2.60 per ton.

No development work has been done at this locality.

Our knowledge of the bedrock geology is far too incomplete to afford a sufficient foundation of facts in an inquiry as to the source of the gold.

Diligent search in this district has, so far, failed to reveal free gold in the quartz or in the country rock, but many quartz veins and stringers have been discovered, which, when assayed, show traces of gold, and often as much as $7 or $8 to the ton, but none of payable value. Fragments of vein quartz and schists, with particles of gold attached to them, are of frequent occurrence, showing conclusively that they are of vein origin or from impregnated zones.

The wiry and angular appearance of the gold sometimes found in the placer deposits indicates a local source.

On Highet creek and on Dublin gulch it is believed that the gold has its origin in the drainage basins of these streams. On Ledge creek the evidence points the same way, but it is not so conclusive. On Duncan creek the gold has suffered greatly by attrition, is much water-worn, and contains no quartz. But this stream has a large drainage basin with steep grades, and sufficient causes have been at work to reduce the gold to its present state without precluding its local origin.

The fine gold in the benches of wide valleys and in the river bars has its source, in all probability, in an older drainage system, and, having been carried by ice and water in company with gravels, has become finely divided by the time it reached its present destination. It is generally well understood by miners and prospectors that the present concentration of gold in placer deposits is due to the slow wearing and carrying away of immense quantities of bedrock, and that the gold, being indestructible and so much heavier than the material that contained it, slowly accumulated.

Yet surprise is still often expressed that in a country so rich in placer gold no payable quartz is found, or, if quartz leads are found, they are so frequently barren. It should be further understood that the visible amount of bedrock worn away, that is, the amount which has been removed to make the present valleys, did not furnish all the gold, but that hundreds, probably thousands, of feet above that have been eroded. The question of time, which enters into all geological problems, is so profound that to many individuals the source of the gold will forever remain a mystery.

While, hitherto, prospecting has not revealed any payable quartz veins, it is by no means implied that they do not exist. The amount of bedrock exposed to the prospector's view is very small, and only seen at intervals in such places as canyon walls, here and there on streams or on a few ridges above timber line; everywhere else it is concealed beneath the forest covering, the moss and the drift. Another adverse factor is the shortness of the season during which the ground is uncovered by snow and prospecting for quartz can be carried on.

In consequence of the reverses met with by the miners on lower Duncan creek, and the Tanana stampede of this year, which drew many of them to Alaskan territory, no prospecting for new creeks was done last summer, and no new discoveries were recorded.

The experience of the miners during the last few years has given them a better knowledge of the conditions peculiar to the country and the kind of ground most likely to afford good pay.

The gold-bearing rocks are widely distributed, and a great deal of the country underlain by these rocks is still unprospected.

To work to advantage in this country the prospector should be equipped with at least one year's outfit of provisions and clothing.

Freight from Dawson is delivered by the steamer *Prospector* at Mayo or Gordon, on the Stewart river, at the rate of ten cents a pound. In winter this freight is delivered on the principal creeks at from three to six cents a pound. During summer the rate is fifteen cents to Discovery on Duncan creek or eight cents to Highet creek. There are stores at Mayo and Duncan creek where clothing and provisions may be purchased.

An excellent road with good grades, suitable for either summer or winter travel, was located and partly cut out this summer by Messrs. Gordon and Davidson from Gordon to Duncan creek, a distance of eleven miles. If a bridge were built over the Mayo river at the outlet of Mayo lake this road could be continued at a small cost over the low divide to Duncan creek near Beliveau creek. The distance then to Duncan creek would be only fifteen instead of twenty-four miles by the Mayo road to the same point.

Pack animals can be used to advantage over most of the country. Fodder is plentiful on the creek bottoms and on the benches, and in many localities hay can be stored for winter use.

Loaded boats or canoes can be poled and tracked up the McQuesten river to the McQuesten lakes.

Miners working in the vicinity of any of the lakes can keep themselves supplied with fresh fish without much trouble. These lakes are all stocked with an abundance of salmon-trout, whitefish, pike and grayling.

Moose are numerous in various parts of the district, and are depended on as a regular source of food.

In addition to these, but not to be depended on for a regular food supply, are the caribou, brown and black bear, and above all, the mountain sheep.

Forest

An adequate supply of white spruce timber of a size sufficient for mining and building purposes can be obtained almost anywhere in the district.

Especially fine groves of this timber were seen on the alluvial flats of the Stewart river, on the north shore of Mayo lake near the eastern end, at the mouth of Duncan creek and at the mouth of Haggart creek. In these groves are many trees of twenty inches diameter, with individuals as large as thirty inches in diameter.

A few small groves of the black pine (*Pinus Murrayana*) were observed on the benches above Mayo river, on the shore of Minto lake, and on the south arm of Mayo lake. The pine is small, none of the trees being more than nine inches in diameter.

Timber line was estimated to be from 4,250 to 4,500 feet above sea level. The balsam fir was the only species represented at that elevation.

1905

Introductory Notes

Dr. Robert Bell, Director, includes the following notes* relative to field work in the Yukon in his Summary Report for 1905.

"Mr. Charles Camsell, assisted by Mr. F. E. Camsell, surveyed Peel River, a large stream flowing northward in Mackenzie District. He left Skagway for Dawson early in the spring and was ready to ascend Stewart River as soon as it was clear of ice. He followed one of the northern branches of this stream in his canoes to a very long portage across the height of land separating it from the source of Wind River, a branch of the Peel. After descending the Peel nearly to the sea, he returned to the Bell River and Rat River, and thence descended the Porcupine to its junction with the Yukon. Here he was picked up by a steamer which took him up to Dawson and he returned in good time to Vancouver. It will be seen by his report that he accomplished a large amount of valuable topographical and geological work in this distant region. Mr. Joseph Keele also proceeded to Dawson before the breaking up of the ice and on the opening of navigation he ascended the Stewart River and continued his investigations of the gold-field on its northern headwaters, which had been commenced the previous year.

"Mr. R. G. McConnell's operations were mostly in the district comprised by the headwaters of the White River, to the west of the Yukon. On his way home in the autumn, he made an examination of the recently discovered silver region of Windy Arm. Soon after his return to Ottawa he prepared a report on this district, which was immediately published under the name of "Recent Mineral Discoveries on Windy Arm, Tagish Lake, Yukon Territory."

"Mr. F. H. Maclaren, who afterwards acted as Mr. McConnell's assistant, preceded him to the Yukon territory and made a survey from Whitehorse westward along the road to Kluane Lake, triangulating the tops of the hills and mountains on either side."

Brief preliminary reports were written by Joseph Keele and Charles Camsell on their explorations of 1905. These were published in the Summary Report for that year, and final complete reports appeared later in the Annual Report, volume XVI (1906) as parts C and CC. These two parts were also released together as a separate publication, and are reproduced on subsequent pages of this volume. The preliminary report of Mr. Keele's work contains notes not in the final report, whereas all the information in Mr. Camsell's preliminary account is included in his later report and for this reason is omitted from this volume.

HEADWATERS OF WHITE RIVER

by R. G. McConnell

Work was continued during the season of 1905 in the district about the head of White river. The time available for work in this distant region is somewhat brief as the summer is short and a considerable portion of it is occupied in travelling. On this account the examination of the district neces-

*Sum. Rept. 1905, p. 14 (1906).

sarily partook of the character of a reconnaissance. A topographic survey of the district was made by Mr. F. H. Maclaren, the topographer of the party.

Topography

The region examined lies along the landward base of the St. Elias range, east of the Alaskan boundary, and is included in the drainage basin of White river, one of the principal western tributaries of the Yukon river.

The northeastern slope of the St. Elias range is largely drained by various branches of White river, the principal of which are the Kluane, Donjek and the Generk rivers. The trunk stream bends to the northwest and crosses the Alaskan boundary before reaching the mountains.

The Kluane river flows out of Kluane lake, a large sheet of water about forty miles in length, lying along the base of the St. Elias range, and fed mostly by Slims river, flowing from the Kaskawulsh glacier.

The Donjek is a typical glacial stream. Its muddy waters, flowing in numerous branching channels, spread out in seasons of flood across a bare gravel flood plain from one to three miles in width. The channels change continually, new ones being constantly opened, and old ones blocked, by the rapid, overloaded streams. Bars easily fordable at one hour are often impassable the next.

The Donjek appears to issue from a large glacier which occupies the whole width of its valley a few miles inside the mountains. I was informed, however, by a prospector who had explored its upper waters, that the glacier is fed by an ice stream descending a tributary valley from the southwest and that the upper portion of the main valley is free from ice and is partially wooded.

The Generk, though scarcely twelve miles in length, carries a large quantity of water and is one of the principal feeders of White river. It heads in the Klutlan glacier and flows northward parallel to, and a few miles east of, the Alaskan boundary. Like the Donjek, it has built up a wide gravel flood plain through which it winds in a multitude of interlacing channels.

The Klutlan glacier has a width, at present, of from two to four miles. It has evidently receded rapidly in recent years as it is bordered on the south by a wide belt of rough morainic country now free from ice. Its rate of motion is slow, and in places it appears to be stationary, as trees occur growing on shallow soil underlaid by clear blue ice. The lower portion and sides of the glacier are buried in debris. A ridge of fresh uncovered ice in the upper central portion of the glacier, only seen from a distance, suggests an active glacier over-riding an older almost stationary ice and gravel mass.

The St. Elias Alps, the principal topographic feature, form the southwest boundary of the district, and extend to the sea. The mountains and mountain ridges of this range are characterized by extreme boldness of outline. Steep slopes, precipitous cliffs and high broken peaks and crests prevail. The larger streams such as the Donjek and St. Clair have cut deep, wide valleys back into the heart of the range, while the smaller ones are usually inclosed in narrow steep-sided and often impassable cañons. The central portion of the range and all the higher mountains are covered with deep continuous snow fields, and glaciers-- some of the first magnitude—are present everywhere.

The St. Elias range is bordered along its whole northeastern front by a wide continuous depression occupied in different portions of its length by a number of small streams. The depression is crossed transversely by all the large streams flowing from the range and evidently antedates by a long period the initiation of the present drainage system. The summit of the depression between Kluane river and the Donjek has an elevation of 1,500 feet above the former, and between the Donjek and the Generk of about 700 feet.

East of the depression is a broken upland cut by a system of interlocking valleys into mountain groups and ridges usually rising from three to four thousand feet above the valley flats. The mountains while rugged in places are more worn and are tamer in appearance than those in the St. Elias range, and their inferior height has also prevented the great accumulation of snow and ice which forms such a conspicuous feature of the latter.

Forest

The forest trees are few in number and include only the white and black spruces (*Picea alba* and *P. nigra*), the aspen (*Populus tremuloides*) and, occasionally, the balsam poplar (*Populus balsamifera*), and the birch (*Betula papyrifera*). The forest is sparse as a rule and ceases at an elevation of 4,000 feet above the sea.

Geology

The geology of the district proved less interesting than was expected, as the older rocks along most of the St. Elias range and for some distance eastward, are buried beneath a great thickness of comparatively recent effusive and fragmental volcanics.

Tertiary

A band of rocks referred to the Tertiary follows the St. Elias range from the Duke river to the St. Clair. They are well exposed on a small stream which enters the Donjek from the west a mile above the mouth of Wade creek. They consist here mostly of grayish conglomerates often only slightly indurated, formed of smooth and well rolled pebbles of quartz, quartzite, slate, chert and diorite. A band of red, iron-stained conglomerate occurs at the base of the formation, derived mostly from the debris of underlying dioritic rocks. With the conglomerate are beds of grayish and yellowish tufaceous sandstones, dark, often carbonaceous shales, and occasional beds of lignite.

The conglomerates and associated clastic beds of the Tertiary alternate with numerous lava sheets from fifteen to one hundred feet in thickness which appear to be contemporaneous with them. The lava sheets are usually andesitic in character and, in places, are slightly vesicular. They have smooth surfaces and decrease in thickness gradually towards their termination. They conform perfectly with the inclosing clastic beds even when the latter are steeply tilted. No dikes connecting with sheets were observed. The vulcanism which accompanied the deposition of the Tertiary beds was of long duration, as the latter are overlaid by at least 4,000 feet of effusive and fragmental volcanic rocks.

The tertiary beds which outcrop along Maple creek consist mostly of shales and sandstone with some conglomerate and an occasional lignite seam. On Granite creek and east of the St. Clair river conglomerate is the principal constituent of the formation.

The tertiary beds are strongly folded in places, especially near the mountains, and therefore antedate in age the last movements which produced the St. Elias range. No determinable fossils were obtained from them.

Mesozoic Beds

The mountains of the St. Elias range fronting on Kluane lake are largely built of hard greenish tufaceous beds alternating with dark shales, breccias and, occasionally, agglomerates. Similar rocks outcrop at the cañon of Duke creek and also at the lower cañon of Burwash creek. The beds of this series, as a rule, are sharply folded and, in places, are overturned and broken. The rocks, usually hard, are more or less altered, and occasionally pass into green chloritic schists.

Specimens of the Triassic fossil *monotis subcircularis*, were obtained from a band of dark shales outcropping near the centre of the lower cañon of Burwash creek. It is unlikely that the whole series is referable to one period as, in places, it is many thousands of feet in thickness. It probably represents the product of repeated volcanic outbursts, possibly continued into the Tertiary.

Upper Palæozoic

The rocks referred to the upper Palæozoic consist mostly of massive limestones and marbles associated with hard shales and slates and feldspathic sandstones. A good section of these rocks is displayed along the Donjek valley from the point where it leaves the St. Elias range up to the Donjek glacier, a distance of about seven miles. The outer range of this point is built of diorite. The diorite is followed by a wide band of crushed, reddish weathering limestone underlaid by grayish massive limestones and alternating limestones and shales. The latter are succeeded by feldspathic sandstones and limestones, both holding fossils of Carboniferous age. The tufaceous beds are cut by diorite, above which is a second band of massive gray limestone, followed by dark slates, altered in places into a schist. The slates are succeeded by reddish granites and diorites.

The limestones and associated rocks strike in a northwesterly direction and dip uniformly to the northeast at angles of from 30° to 70°. This outward dip is unusual in the great mountain ranges of the west, and is not a constant feature of the St. Elias range, although it occurs at several points.

At the head of Burwash creek the outer range of the St. Elias mountains is built of massive limestone, and bands of limestones and shales similar to those on the Donjek but dipping at a high angle in the opposite direction. North of the limestones—and apparently underlying them—are hard feldspathic quartzites, dark shales and ironstained tufaceous beds. These beds have a nearly vertical attitude and their age relationship to the limestones is uncertain.

The mountain groups northeast of the trail from Burwash creek to the Donjek are built largely of slates, hard tufaceous rocks and limestones similar to those in the St. Elias range. West of the Donjek the limestones disappear and the rocks outcropping along the valleys of Wolverine and Harris creeks consist mostly of hard, imperfectly cleaved slates and tuffs, cut by numerous diorite dikes and by a granite area.

The rough grouping of the clastic rocks of the district into the three series briefly described above is only intended as a provisional one and will doubtless be greatly modified when the region is examined in detail.

Massive Igneous Rocks

Andesites and Basalts

Effusive rocks have a wide distribution in the district. A large area commencing within a few miles of Kluane lake crosses Duke river valley and extends northward to the 'gap' of this stream. A second small area — probably a disconnected portion of the first—occurs south of upper Burwash creek. Between the Donjek and the Generk the mountains of the St. Elias range, and a wide flanking plateau, are built entirely of these rocks and they extend westward across the Generk to the Alaskan boundary.

The effusives rest on the Tertiary north of the Donjek and are therefore the youngest rocks in the district. The lava sheets in the Duke river area are nearly horizontal and show no signs of disturbance. North of the Donjek the sheets are often sharply bent and in places are broken and faulted.

The effusives in this series consist mainly of augite andesites of a somewhat basic type, and basalts. The sheets range in thickness from a few feet to several hundred feet, and are usually separated by tufaceous beds varying in texture from a fine ash to a coarse breccia. The series has a minimum thickness of 5,000 feet.

Amygdaloids

Bands of a green amygdaloidal rock occur at several points in the district, usually associated with the Mesozoic tufaceous beds. The upper portion of the lower cañon of Burwash creek is cut through this rock, and it was also found at the upper cañon of Tatamagouche creek and on one of the creeks flowing into Kluane lake. It is important as it is supposed to be the source of the native copper which occurs loose in so many of the creeks of the district. Lithologically it is a vesicular diabase. The augite in the section examined is mostly altered to chlorite, and the cavities are filled with calcite usually surrounded by a ring of chlorite. A similar rock—also associated with copper deposits—occurs in the Windy Arm district.

Gabbro-diorite

This is a dark gray rather fine texture intrusive, widely distributed in stocks and dikes throughout the district. It is a hard rock and in the St. Elias range usually weathers into high bold peaks. It cuts the beds of the Mesozoic series but is older than those referred to the Tertiary. While usually massive it is slightly sheared in places and is occasionally seamed with small quartz veins.

The mineral constituents of the gabbro-diorite exhibit considerable variety in different sections. In places the rock is a typical diorite consisting essentially of hornblende, some biotite, and labradorite. This type passes by the substitution of augite for hornblende into a gabbroic variety, and by the addition of quartz and microperthite into a grano-diorite.

Quartz Porphyrite

A yellowish porphyritic rock showing, in thin sections, a fine grained quartz and feldspar base, through which crystals of a plagioclase feldspar, biotite and quartz, are porphyritically distributed, outcrops in considerable masses along Burwash creek. It is probably the youngest intrusive on the creek.

Dunite

Areas of dunite, partially altered in places into serpentine, occur on Burwash creek and on a branch of Quill creek.

Economic Geology

Coarse gold occurs in nearly all the streams in the district except those flowing over the recent volcanic rock, but no rich concentrations have so far been found. Brief descriptions of all the creeks worked, with the exception of Arch creek, are given in the Summary Report of 1904 and need not be repeated here. Ruby creek, the centre of mining operations in 1904, is now almost abandoned and the miners have moved on to Fourth-of-July creek, a parallel stream flowing out of the same range. A few claims are being worked on Fourth-of-July below the mouth of Snyder creek. A feature of the workings of this creek is that the auriferous gravels rest on a band of boulder clay which constitutes the bedrock. The boulder clay band has not been pierced, and there is a possibility—as pointed out in last year's Summary—that pay-gravels may exist beneath it. The gravel bed overlying the boulder clay is shallow and easily mined, but carries comparatively light values.

A large amount of work was done on Bullion creek by the Bullion Hydraulic Co. This company has taken over most of the ground below the cañon and spent the season in installing a hydraulic plant. A flume five feet by three and a half feet, with intake on Claim No. 26, has been built down the valley to Claim No. 48, a distance of about a mile. In places where the valley slopes were favourable the flume is replaced by short ditches. The grade of the creek is steep and a head of 175 feet is gained in this distance. The water is supplied to the monitor through a pipe 1,200 feet in length and thirty-six inches in diameter at the intake. At the time of my visit excavations for a bedrock flume were in progress. The monitor was employed for this purpose and appeared to be doing very efficient work. Preparations were not completed in time to admit of a satisfactory test of the creek before the season closed.

A number of claims were worked on Burwash creek throughout the season, both above and below the cañon, with varying results. The values in the upper part of the creek have proved generally unsatisfactory and some of the claims have been abandoned. A stretch of fair ground several claims in length has been found in the valley about a mile above the cañon and a second one at the foot of the cañon. The returns from the best claims seldom exceed ten dollars per day per man. Mining on Burwash creek is attended with peculiar difficulties; the creek is subject to sudden floods and on several occasions last season wing dams and drains—the result of weeks of hard work—were destroyed by the rushing waters in a few minutes.

Some prospecting has been done on Tatamagouche creek, a northern branch of Burwash creek. This creek is similar in character to Burwash creek and cuts the same rocks. It enters Burwash creek through a long cañon above which the valley is wide and open.

Further to the west is Arch creek, the latest discovery in the district. This stream heads with a branch of Quill creek and flows westward into the Donjek. Its grade averages about 300 feet to the mile. Like most of the creeks of the district the valley contracts at one point into a narrow cañon. The cañon is situated about a mile above the mouth of the valley and is about three quarters of a mile in length. Half a mile above it is a second small cañon 200 yards in length, above which the valley widens out and is bottomed with narrow flats and bordered in places with terraced slopes.

The rocks outcropping along the valley consist of hard tuffs, slates and limestones cut by several small diorite masses. The name of the creek is derived from an arch-like opening in a band of limestone crossing the cañon through which the stream has cut a passage. The slates and tuffs are traversed by small quartz veins from which the gold in the creek has probably been derived.

At the time of my visit a few claims were being worked in the cañon, where the gravels are comparatively shallow. In the upper part of the valley the gravels deepen, and the few holes sunk have failed to reach bedrock. The gold obtained is found on or near bedrock, and consists mostly of heavy grains and small nuggets. The largest nugget found was obtained from No. 9 claim in the cañon, and weighed over three ounces. It contained considerable quartz, and its rough surface showed that it had not travelled far. No ground yielding more than good wages has been found on the creek up to the present.

It is somewhat remarkable considering the number of creeks in the district on which coarse gold has been found, and the wide area over which they are distributed, that occasional rich concentrations have not been found. The chances of such discoveries are, of course, not by any means exhausted, as none of the creeks have been fully prospected, and some of them have scarcely been touched, and it is this which keeps the miner in the field. The present yield of the best claims of from $6 to $10 per day can hardly be considered wages in a region where the cost of supplies is so excessive and the working season is so short and broken.

Copper

Native copper is almost as widely distributed in the creeks of the district as gold. It is found on Bullion, Sheep and other creeks flowing from the St. Elias range, and also on Burwash, Tatamagouche and Arch creeks, in the region between Kluane river and the Donjek. It is not found on Ruby, Fourth-of-July, or any of the streams cutting the old schists of the Ruby range.

The principal copper creek in the White River district is Kletsan creek. This stream is situated in Alaska, about four miles west of the International Boundary. It was examined by Mr. A. H. Brooks of the U.S. Geological Survey in 1898. Brooks found that the stream copper, in part at least, was derived from calcite veins cutting a dioritic rock exposed along the valley. These copper-bearing rocks do not extend far in an easterly direction, as they are soon buried beneath a great accumulation of young volcanic rocks.

Areas of a dioritic rock apparently similar to that on Kletsan creek occur on most of the copper-bearing creeks in the Kluane district, but no mineral discoveries have so far been made in them.

The upper part of Burwash Creek cañon is cut through a green, often iron stained, diabase amygdaloid. This rock is cut by a few small calcite veins, which are usually stained with copper and carry small quantities of chalcopyrite and occasional grains of native copper. Similar copper-stained amygdaloids occur on Tatamagouche and several other creeks in the district. No veins of commercial importance have been found in them up to the present.

Native Silver

Occasional coarse grains and small rough nuggets of native silver occur with the gold on Burwash and Arch creeks.

Coal

Lignite coal of good quality occurs throughout the Tertiary area extending along the foot of the St. Elias range from the Donjek to the St. Clair. The beds (veins) vary in thickness from a few inches up to four feet.

WINDY ARM DISTRICT

by R. G. McConnell

On the way back from the White River country a few days were spent late in the season examining the recent mineral discoveries on Windy Arm, Tagish lake.

Situation and Communications

The principal ore deposits so far discovered in this district occur on the west side of Windy Arm, a southerly branch of Lake Tagish. Tagish lake forms part of a chain of long narrow lakes, including, in order from north to south, lakes Lindeman, Bennett, Nares, Tagish and Marsh, which commence well within the Coast range of mountains and extend northward and eastward for a distance of nearly seventy miles. The general direction of these lakes is north and south, with the exception of Lake Nares and the upper part of Tagish lake, which have an east and west alignment. Windy Arm joins Tagish lake near its head and extends south for a distance of twelve miles. Its course is nearly parallel to that of Bennett lake, and the two sheets of water inclose an area of high mountainous country about eight miles in width, the scene of the principal recent discoveries.

The White Pas and Yukon Railway affords easy communication to the new mining district. This line, after crossing the Coast range, follows the east shore of Bennett Lake to Caribou Crossing, at the foot of the lake, at which point steamers run to Conrad City, on Windy Arm, the shipping point of the mines. The total distance from tide water at Skagway to Conrad City is 79 miles, of which 67·5 miles is made at present by rail and 11·5 miles by water. A railway can easily be built from Caribou Crossing along the shores of Lake Nares, Tagish lake and Windy Arm to Conrad City, and surveys for one have already been made by the engineers of the White Pass and Yukon Railway. A second route from Log Cabin station, on the main line of the White Pass and Yukon Railway, above Bennett lake, by way of Tutshi lake to Windy Arm, has also been proposed. The distance to tide water would be reduced considerably by this route, but the mileage of new line necessary would be greater.

Character of Country

The country bordering the northeastern slope of the Coast range, including the Windy Arm mining district, may be characterized generally as consisting of a system of wide valleys, often interlocking in a peculiar manner, separated by mountain groups and ridges rising from 4,000 to 5,000 feet above the valley flats. Most of the valleys are bottomed at intervals with long narrow deep lakes, due to the blocking of the channel at various points with glacial drift. The uplands are usually fairly regular in outline, but in places are exceedingly rugged and are often deeply incised by the numerous small streams which flow down their sides.

The forest growth is sparse and is confined to the valley flats and lower slopes of the mountains. At an elevation of 2,000 feet above the valley bottoms the forest practically ceases. The principal trees in the district are the white and black spruces, the aspen, the balsam poplar, the balsam fir and the black pine. The supply of rough lumber within easy distance of the camp suitable for ordinary mining purposes is ample for some years at least.

Geology

The mineralized area on Windy Arm is situated a few miles northeast of the long granite batholith of the Coast range. This great igneous mass extends from the southern boundary of British Columbia in a northwestern direction to latitude 62°, north, a distance of fully 1,000 miles, and constitutes one of the largest continuous granite areas in the world. Mineralized areas have been found at a number of points in both the older clastic and younger intrusive rocks, flanking the Coast range batholith, and it is probable that further discoveries will be made, as the adjoining country, especially on the landward side of the range, has so far been only imperfectly prospected.

The clastic rocks flanking the Coast range granite in the vicinity of Bennett and Tagish lakes, consist of crystalline limestones, coarse slates passing in places into schists and interbanded with quartzites, limestones and hard, fine grained cherty beds, and dark argillites alternating with tufaceous sandstones, coarse conglomerates, and occasional limestone bands.

A section from Tagish lake up Windy Arm and along the short valley connecting Windy Arm with Tutshi lake was studied in some detail. Near the mouth of Windy Arm the rocks consist of light grayish heavily bedded crystalline limestone, striking in a northwesterly direction. These rocks have an extensive development along the southeastern shore of Tagish lake and the lower part of Taku Arm. They also extend in a wide band from a point near the west end of Tagish lake southeastward to Atlin lake.

The limestones are succeeded going south along Windy Arm by a set of beds which will be referred to as the Tagish series. This series consists largely of dark, hard argillaceous rocks, coarsely bedded and occasionally passing into impure quartzites. The slates are interbanded in places with crystalline limestones and also include numerous beds and bands of fine grained compact cherty rocks, probably hardened by the infiltration of siliceous waters. Occasional bands of amygdaloid are also present. The relationship of the Tagish series to the crystalline limestone was not ascertained. The latter is probably Carboniferous in age.

The Tagish series is replaced ascending Windy Arm by basic igneous rocks usually porphyritic in character. The porphyrites and associated rocks outcrop along the shores of the lake for a distance of five miles and are then succeeded by a series of clastic rocks for which the name Tutshi series is proposed. The Tutshi series consists mostly of dark well cleaved argillites, softer and less altered than those in the Tagish series. The argillites alternate in places with fine grained tufaceous sandstones and occasional beds of grayish limestone. Bands of conglomerate and agglomerate also occur in this formation, the former holding well rounded pebbles of slate, quartzites and granite. The Tutshi series resembles lithologically a formation in the

Atlin district, holding fossils supposed to be of Jurassic age (Part B. Annual Report Geological Survey of Canada, Volume 12, 1899, page 26).

A parallel section along the lower part of Bennett lake cuts the same formations as those exposed on Windy Arm, except that the Tagish series is partly replaced by an outlying granite area. The northeastern boundary of the main Coast range granite mass crosses Lake Bennett at Pavey station, five miles below the head of the lake.

The massive igneous rocks of the district consist of granites and porphyrites and allied rocks.

A granite area about three miles in width occurs at the lower end of Bennett lake, and strikes southward towards the head of the south branch of Montana creek. The granite is a medium grained unsheared gray rock consisting of quartz, orthoclase, oligoclase biotite and hornblende. Dikes of a similar character cut the Tagish series on Windy Arm.

The porphyrite is the most important rock, economically, in the district, as most of the veins discovered up to the present occur in it. It crosses from Windy Arm to Bennett lake in a band from three to five miles in width, and also extends for some distance east of Windy Arm. It is a dark grayish, usually rather fine grained rock, distinctly porphyritic as a rule. Thin sections show feldspar phenocrysts scattered through a crystalline base, consisting mostly of small feldspar crystals and chlorite. Augite is occasionally present, and calcite is abundant in the sections examined. In many places the porphyrite is heavily charged with iron, and weathers to a rusty colour. At Red Deer mountain it either passes into, or is replaced by, a medium grained rock with the character and composition of gabbro.

The principal structural feature of the porphyrite-gabbro are the systems of strong jointage planes everywhere present. The joints, like the veins, show little parallelism in either dip or strike in different parts of the area.

General Character of Veins

The largest and most persistent veins so far discovered occur in the porphyrite area. They are not, however, confined to this formation, a few occurring in the granite and some, also, in the slates. The veins occupy typical clean-cut fissures with regular walls often slickensided and grooved. They are comparatively narrow but as a rule exhibit remarkable persistency in strike. The Uranus vein, with a width of from one to four feet, has been traced by small openings and surface showings for a distance of about 1,500 feet and may extend much farther, while the Montana vein, with a maximum width of five feet in the portion explored, has apparently been cut at a distance of 1,600 feet from the main workings and may also, of course, be very much longer. The Venus No. 2 lead (the largest seen by the writer) has a width of nine feet at two openings about 400 feet apart, and must extend for long distances in both directions. Numerous other veins such as the M. and M., the Joe Petty and Venus No. 1 are traceable by surface outcrops for several hundred feet. Portions of all these veins are concealed by slide rocks, and their full length was not ascertained.

The dip and strike of the veins are exceedingly irregular. The Montana vein strikes N. 43 W., while the direction of Venus No. 2 is about N. 42 E. The M. and M. strikes nearly north and south. The dips are nearly all to the south and west and vary in steepness from 12° in the Montana to 50° in Venus No. 1.

The gangue in all the veins is mainly quartz. Single and multiple lines of interlocking quartz crystals are a constant feature. In a few instances, portions of the vein-filling consist of alternating layers of quartz and country rock. The latter, in such cases, is always heavily mineralized, usually with iron, and weathers to a rusty colour.

The list of metallic minerals contained in the veins as identified in the field, and in the laboratory of the Survey from specimens brought back by the writer, includes the following:

Native Silver. Occurs in small spangles and in wire form in the Montana and Uranus veins.

Argentite. Is found in some of the veins but is not abundant.

Stephanite. Occurs in several of the veins and is an important source of silver.

Freibergite. A dark, highly argentiferous mineral occurring in some abundance in the Joe Petty, Montana, and some of the other claims has been referred tentatively to this species. A partial analysis by Mr. Connor showed it to contain copper, silver, zinc, arsenic, iron, sulphur and antimony, the constituents of freibergite. The copper percentage in the specimen examined amounted to 9 per cent and the silver to 37 per cent.

Pyrargyrite (Ruby Silver). This rich silver mineral occurs in most of the veins, sometimes in considerable quantity.

Galena. This mineral occurs in all the veins and is usually highly argentiferous.

Tetrahedrite. Argentiferous tetrahedrite occurs in small quantities in the Montana, M. and M., and probably in other claims.

Chalcopyrite. Occurs in the Silver Cliff and other claims east of Windy Arm.

Native Copper. Occurs in the Millet, Fedora and other claims east of Windy Arm.

Malachite and Azurite. Green and blue incrustations and stains referable to the copper carbonates and due to the leaching out of the copper in the tetrahedrite and freibergite occur in most of the veins.

Specimens of a green mineral stated to be a silver chloride proved on examination to be a copper carbonate. It is possible that such a chloride is present in some of the veins but it could not be detected in the specimens examined.

Iron Pyrite. Common in all the veins.

Arsenopyrite. Occurs in a number of the veins but is usually subordinate in quantity to the iron pyrite.

Pyrrhotite. Occurs in the Big Thing group.

Sphalerite. Zinc-blende occurs sparingly in most of the veins examined.

Mining Development

Montana Vein

This important vein is situated on a bleak hillside about 3,700 feet above Windy Arm and 5,860 feet above the sea. An aerial tramway, four miles in length, connecting it with Conrad City, on the lake shore, was nearly completed at the time of my visit. At present, all supplies and materials for the mine, including firewood, are packed on horses.

The principal workings consist of a drift 180 feet in length. The drift pierces 50 feet of slide rock, then meets and follows the vein. A small fault, with a displacement of seven feet, was encountered at one point. The strike of the vein is N. 43 W., and the dip 10 to 12 to the S.W. The width of the vein increases from about two feet near the mouth of the drift to nearly five feet at the face. Some stoping has been done and a considerable quantity of ore has been shipped.

The ore minerals include native silver, pyrargyrite, argentite, freibergite (?), tetrahedrite, galena, and iron and arsenical pyrites. The distribution of the minerals through the quartz gangue is somewhat irregular. In places, especially near the walls, the vein matter is so thoroughly impregnated with silver bearing minerals that it is rich enough to ship without much sorting—that is, it contains values of $80 per ton and over. The leaner portion of the vein will require concentration.

The principal values in the vein are in silver. The ferruginous portion of the vein is stated to also carry some values in gold.

At the time of my visit a second drift, intended to cut the Montana vein at a distance of 1,600 feet in a northwesterly direction from the main workings, was being driven, mostly through slide rock. The two workings are connected by a line of float ore and in places where the surface is bare by outcroppings; the management were confident that the vein extended at least that far. Since leaving the camp the vein (or a vein stated to resemble the Montana vein in general character) is reported to have been struck.

Uranus Vein

The Uranus vein is situated just above the forks of Pooly creek, a small stream tributary to Windy Arm. It is distant from the Montana vein about a mile in a southerly direction, and from the lake about a mile and a half. The elevation above the lake is approximately 2,000 feet. The Uranus vein is traceable by numerous surface outcrops in a direction a few degrees east of south from the north to the south branch of Pooly creek, a distance of about 1,500 feet. The vein crosses a high ridge separating the two creeks and is thus exposed naturally in depth for some hundreds of feet. A tunnel starting at the south fork has been driven 180 feet along the vein, which dips to the west at an angle of about 40° and varies in width from a few inches to three or four feet. It carries considerable quantities of highly argentiferous galena and also some native silver, ruby silver and iron and arsenic sulphides. A few tons of sorted ore have been shipped.

Other important veins in the vicinity of Pooly creek and its branches are the Joe Petty and the M. and M. The Joe Petty is a very strong vein. A shaft following the lead has been sunk at one point to a depth of about fifty feet, showing a vein fully six feet in width. The vein material consists of alternating bands of quartz and silicified and mineralized country rock carrying layers and scattered grains and crystals of the rich silver and silver-bearing minerals of the district. The M. and M. is a much narrower vein seldom exceeding twelve to fifteen inches in thickness, but is very persistent in strike. It is traceable on the surface for several hundred feet at least. This vein is especially rich in places in high grade silver minerals such as pyrargyrite, stephanite and the sulph-antimonite referred as freibergite.

Another important group of claims is situated south of Pooly creek and about half a mile west of Windy Arm. This group includes, among others, Venus No. 1, Venus No. 2, and Ruby Silver. No work was being done on them at the time of my visit. Venus No. 2 is an exceedingly strong vein.

The only work done on it consists of two shallow openings about 400 feet apart. These show a vein fully nine feet in width. The vein-filling consists of three and nine inches of quartz along the foot wall, followed by alternating bands of quartz and decomposed and mineralized country rock. The ore is principally argentiferous galena. Good assays in gold are stated to have been obtained from this vein. Venus No. 1 is a smaller vein. A shaft following the vein has been sunk on it to a depth of fifty-two feet. This shows a quartz vein, increasing in width from ten inches at the surface to about thirty inches at the foot of the shaft, bordered by several feet of decomposed and mineralized country rock, fissured parallel to the vein. Fifteen tons of ore obtained in sinking the shaft and shipped to outside smelters are stated to have averaged $65 per ton in silver. Ruby Silver is a narrow siliceous vein spotted, in places, with the mineral from which it takes its name. Very little development work has been done on it.

South of the Venus group, and apparently in the same zone of fracturing, are the Red Deer and Humper Claims. The Humper vein, as shown in a couple of small openings, has a width of about two feet. The quartz is bordered above and below by about a foot of decomposed iron-stained country rock which might be considered part of the lead. A shaft twelve feet in depth has been sunk on the Humper Extension, an adjoining claim on the east. The vein followed has a width of about fifteen inches. The ore on the dumps showed galena, ruby silver, stephanite and green copper carbonate, probably derived from tetrahedrite.

About a mile north of the Montana is the Big Thing group. The conditions here are different, as the country rock is granite. A considerable body of loose ore, principally argentiferous galena, evidently derived from a strong vein, occurs on one of the claims. The vein had not been determined at the time of my visit. A number of other veins are reported to cross the various claims, but were not examined.

The claims briefly described above comprise only a small proportion of those staked in the district, but on most of the remainder little or no development work has so far been done, and the time at my disposal did not permit me to make a systematic examination of them.

The general outlook for the camp is considered exceedingly promising, and its opening up marks an important event in the mining history of the country.

The mining conditions are not unfavourable. Most of the veins are situated at distances of from half a mile to four miles from the lake and at elevations of from twelve hundred feet to three thousand six hundred feet above it. Aerial tramways can therefore easily be constructed for the carriage of the ores to the lake shore for concentration and can also be used to take supplies to the mines. Miners' wages during the past season amounted to $3.50 per day for eight hours work, and ordinary labourers obtained the same amount for ten hours work. The cost of supplies, considering the short distance to the seaboard, and the almost continuous rail connexion, ought to be moderate. The climate, while severe during a portion of the year, will have little effect on mining operations.

A RECONNAISSANCE SURVEY ON THE STEWART RIVER

by Joseph Keele

I left Ottawa on March 25, with instructions to make an examination of that portion of the Stewart river above Frazer falls, and as many of its tributaries as time permitted. I reached Whitehorse on April 6, where some delay was occasioned owing to the non-arrival of canoes, and from this point travelling partly on the ice and partly on the Yukon river, arrived at Dawson on May 18. Provisions for the whole season, and a camping outfit, were procured at Dawson, and, accompanied by two men, I embarked on the steamer '*Prospector*' on May 22, her first trip for the season up the Stewart river. We reached Frazer falls, a distance of 260 miles from Dawson, five days later. Here I was joined by a third man and the party was complete.

When we arrived at Frazer falls we found the Stewart river in flood and hourly increasing in volume owing to the unusually warm and early spring. The river reached its maximum height on May 31 and did not subside sufficiently to allow us to proceed in our canoes until June 7. During this period the water rose to a height of 25 feet above low-water mark at the head of the falls; it became extremely muddy, and a never-ceasing burden of floodwood and living trees torn from the banks was borne on its surface. This is the highest water which has occurred since 1898. The river afterwards rose on three occasions to a height of from 12 to 18 inches each time, the last rise being on July 3, and caused probably by the melting of snow on the higher peaks in the watershed ranges.

The only work previously done in this region was an exploratory topographic survey by Mr. J. J. McArthur as far as the mouth of Hess river, or South branch of the Stewart, in 1898. Consequently the greater portion of the season was devoted to making the necessary surveys for the preparation of a map.

A micrometer and compass survey was made from Mayo landing, a distance of 36 miles below Frazer falls, to a point 390 miles up the Stewart river; and for a distance of 45 miles up the Beaver river. Track surveys were made of the entire course of the Ladue river, and a portion of Rackla river. A good general idea of the relief of the region was obtained by a system of triangulation and sketches made with a small transit from several prominent mountain peaks. The surveys are now being plotted, and material will thus be furnished for an approximately correct map of a part of the country that, up to the present, has been almost entirely unknown.

The men who assisted me in the work are miners in the Duncan Creek district, who had an interest in the development of the country. They were highly efficient in every phase of the various duties assigned to them, and rendered excellent service.

The Stewart river above Frazer falls drains an area of about 120 miles in extent in an east and west direction, and about 80 miles north and south.

During its course through this area it receives four important tributaries, the principal one being Hess river or the South branch, which enters from the east at a distance of 55 miles from the foot of Frazer falls, following the windings of the river. Twenty-eight miles farther, Lansing river also enters from the east. Ladue river enters from the west at a distance of thirty-two miles above Lansing, and from the same direction Beaver river enters about seven miles above the mouth of the Ladue.

The headwaters of the Stewart river and its branches have their source either in the Ogilvie range to the north or in the Selwyn range to the east. These two mountain chains form the watershed between the Yukon and Mackenzie drainage basins in the region here described.

The entire drainage basin of the Stewart is of a mountainous character, and although much of the upland country of the area is composed of flat topped or gently rounded and wooded hills, there are high flanking ranges or single groups adjacent to the main ranges with peaks which measure from 6,000 to 7,500 feet above sea-level or almost as high as the most prominent peaks in the watershed ranges.

This mountainous region is traversed in several directions by a system of wide, interlocking valleys. The floors of these valleys are graded to as low a level as the character of the country will permit. Not all of them are now occupied by the river and its principal branches, although they all appear to be ancient drainage channels.

Evidences of a former glacial period are met with in various portions of the area. These consist of ice groovings and striae preserved in certain exposures of bedrock, the occurrence of drift at high altitudes, of boulder-clay containing scratched and planed pebbles, and, above all, the characteristic topography which usually results from the smoothing action of a general ice sheet.

Until the observations made in the field have been laid down on the map, it will be impossible to give with precision any account of the geological features of the region. The rocks in general are closely analogous to those met with in the corresponding regions to the south and west.

The area between the Beaver and the Stewart rivers consists mostly of crystalline schists similar to those found in the Duncan Creek mining district, and described by the writer under the name of the Nasina Series in the Summary Report of the Geological Survey for 1904. These rocks appear to extend eastward up the Hess River valley, and are found in a few localities as far south as the Macmillan river. About ten miles below Lansing these schists are replaced by a series of rocks which are evidently much younger. These consist of dark carbonaceous and greenish argillites, and gray shales with occasional narrow bands of black limestone and sandstone hardened almost to quartzite. These rocks are exposed at intervals on the river banks as far as Beaver river.

Above the mouth of the Beaver river no rock appears on the river for a distance of forty-five miles, but beyond this point exposures are frequent. The rocks here consist of sandstones, grits, red and green slates and gray limestone. A section obtained on the bordering mountains to the south of the river shows a thickness of over 3,500 feet of these rocks. These rocks extend eastward for a considerable distance, and a similar series occurs on the Macmillan river.

North of the Stewart and Beaver rivers the mountains are composed principally of heavily bedded limestones and ferruginous slates. All these rocks are mostly of sedimentary origin with the exception of a portion of the crystalline schists, which are altered intrusives. Unaltered intrusive and volcanic rocks are also represented in this area, not, however, for any great extent, but occurring in small detached and irregularly distributed masses.

Several gold seekers entered this country during the Klondike excitement in 1898, but they do not appear to have done much prospecting. Those who passed down the Stewart river, while making the extraordinary journey from Edmonton, were intent on reaching Dawson as quickly as possible, and those who afterwards ascended the river devoted most of their time to hunting and trapping.

The portion of this region which, in the light of past experience, would seem to afford the most likely ground for the prospector in search of placer gold, is the area situated between the Beaver and Stewart rivers.

This area is mostly underlain by metamorphic schists, which are intruded in some places by igneous rocks, such as granite, diorite and diabase, and are similar in character to the bedrock in all the placer camps of the Yukon. Fine colours of gold were obtained in the gravels in many of the small streams along the route, but whether there was sufficient to pay for mining could only be determined by the usual methods of opening up bedrock.

In the area between Hess river and the Lansing river, east of the Stewart, at least three creeks flowing into these streams are said to yield coarse gold. This portion was not examined by the writer. On Congdon creek, which comes in from the east about ten miles below Lansing, good surface prospects were obtained by one of the party.

Above the mouth of Mayo river the gravel bars on the Stewart are only slightly auriferous and have never yielded wages to the bar miner. Beyond the mouth of Beaver river the bars do not appear to be auriferous; the same may be said of the Beaver river, and although fine gold was said to have been found in 1898 on the bars of Rackla river, its principal tributary, no colours could be raised by the writer's party in that stream.

About one mile up, on a small creek nearly opposite the mouth of Rackla river, a small quantity of coarse gold was obtained in the surface gravels.

No gold-bearing quartz has, so far, been discovered in this region. Small bodies and stringers of vein quartz are common enough occurrence in the area of metamorphic schists, but none which contained gold were seen on the portion of the area traversed.

A large body of quartz, in low, rugged ridges, crosses the Stewart valley about ten miles above Hess river, and a similar body occurs on Rackla river below the forks. Both are apparently barren of any mineralization.

There is a small band of native inhabitants living in cabins at the mouth of Lansing river, at which point Messrs. Frank Braine and Percival Nash have established a trading post. A number of Indians from Fort Good Hope on the Mackenzie river make a yearly journey to Lansing, hunting and trapping over the intervening country during the trip. A few white men also make a business of trapping; these confine their operations mostly to the country in the vicinity of Hess river. The principal land quadrupeds are the moose, caribou, mountain sheep, brown and black bear, wolverine, martin, wolf, lynx, fox, marmot, rabbit, beaver, mink and muskrat.

There is an abundance of fish in the rivers and lakes, such as salmon-trout, whitefish, pike and grayling. The king salmon, coming up from the sea to spawn, were observed high up in the Beaver river, and several are caught at Lansing. These were the more vigorous ones, as the majority of the salmon are unable to ascend the Frazer falls.

The Stewart river opened and became free from ice at Lansing on May 10th. There was no frost between May 24th and August 23rd, and during this period the weather was very fine and warm. The snow disappeared almost entirely from the mountain ranges, and only a few of the highest peaks retained any on the first of August.

It was an exceedingly fruitful year in this locality. There was a great profusion of all the native wild fruit, such as blueberries, raspberries and red and black currants. A garden planted by Mr. Braine near his house at

Lansing produced very fine vegetables. All the varieties found in the gardens in the vicinity of Dawson can be grown here.

THE UPPER STEWART RIVER REGION

by Joseph Keele

The Stewart river, one of the principal tributaries of the Yukon, drains an extensive region lying between the basin of the Pelly river to the south, and that of the Peel river to the north. It rises in the Pacific-Arctic watershed ranges and flows in a general westerly direction toward the Yukon valley. It is navigable throughout the season for river steamers as far as Frazer falls, a distance of 200 miles from the Yukon.

Early Bar Mining

The Stewart was one of the first rivers in the Yukon territory to attract the attention of miners. In the year 1883 and for several years following gold was found in paying quantities on the bars along the lower portion of the river.

No bar mining of any account is now carried on, but an occasional miner spends the latter portion of the season when the water is low 'rocking' on some of the numerous bars between Mayo river and Lake creek. The expert in this kind of mining is always sure of at least a grub stake. In 1900 Mr. R. G. McConnell made an examination of the Stewart river as far as Frazer falls. There are no previous records of the river above this point and very little appears to have been known about it previous to 1898. During this and the following year several prospectors crossed the divide from the Mackenzie side and descended the Stewart to the Yukon. In the same years large parties of gold seekers ascended the river, but very few of them went beyond Frazer falls as the reports brought down were not encouraging.

In 1895 coarse gold was first discovered on the streams tributary to the Stewart, and from that time until the present time new discoveries of placer gold of more or less importance have been made each year. The Clear Creek and the Duncan Creek mining districts were established and included all the streams tributary to the Stewart as far east as the Mayo river and its branches.

Although some of the creeks in these districts were rich in placer gold the average remuneration was small. The difficulties and expense of mining and transport, and the inexperience of many of the miners have hitherto tended to keep down the profits and to discourage prospecting.

The area, however, in which it might reasonably be expected to find placer gold is large, and, with cheaper supplies and a better knowledge of the methods of mining best suited to the conditions, future developments and an extension of the productive ground may be looked forward to, as much of the region is yet unprospected.

This report deals with the upper portion of the Stewart river and the adjoining territory, including a part of the country immediately east of the Duncan Creek mining district.

A report by the writer on the latter area is given in the Summary Report of the Geological Survey for the year 1904.

General Description of Region

Stewart River

The Stewart river above the Frazer falls drains an area of about 12,000 square miles. During its course through this region it receives four important tributaries, the principal one being the Hess river, or South branch of the Stewart, which enters from the east at a distance of fifty-five miles from the foot of Frazer falls, following the windings of the river. Twenty eight miles farther Lansing river also enters from the east.

Ladue river enters from the west at a distance of thirty-two miles above Lansing, and about seven miles farther on Beaver river enters from the same direction.

The headwaters of the Stewart river and its branches have their source either in the Ogilvie range to the north or in the Selwyn range to the east.

These two mountain chains form the watershed between the Yukon and Mackenzie drainage basins in this region.

The entire drainage basin of the Stewart is of a mountainous character, and although much of the upland country in the area is composed of rounded and wooded hills, or low ridges, there are also high detached ranges or single isolated groups of mountains with peaks which measure from 6,000 to 7,400 feet above sea level, or quite as high as the more prominent peaks in the watershed ranges.

This mountainous region is traversed in several directions by a system of wide interlocking valleys, mostly occupied by the river and its principal branches. The present drainage is often confused and interrupted by former glacial action, or other causes, and it is not uncommon to find that streams have migrated from one old valley to another by means of a channel of comparatively recent origin. The smaller streams at the headwaters issue from the mountains in narrow rock-walled valleys. These streams are very swift and carry a large burden of debris. In flood time, when swollen with the melting of snow on the summits, they become formidable torrents.

Evidences of a former glacial period are met with in various portions of the area, and the valley slopes exhibit the usual characteristic topography which results from the smoothing action of an ice sheet.

At Frazer falls the Stewart river flows through a gorge three-eighths of a mile long, with a fall of about forty feet in this distance; it is really a rapid, as the grade is fairly uniform. Above this gorge the river still occupies a narrow channel bordered by rock benches, and three short rapids, due to the rock barriers, occur at intervals. Three-quarters of a mile above the upper rapid and six miles from the foot of Frazer falls, Nogold creek enters the Stewart from the west. This is a winding stream with slow current, and a width at the mouth of about seventy five feet. At this point the Stewart river turns at right angles to its former course and enters a wide valley extending northeast and southwest.

This valley joins the present valley of the Stewart below the mouth of Mayo river; it is three miles wide across the bottom and contains a great number of small lakes scattered over the flats adjoining the river. It is bordered by hills having long easy slopes to a general elevation of about 2,500 feet above the flats.

The river appears to have no definite channel in this valley bottom, and, during flood time, when the discharge of water and the speed of the current are greatly increased, it meanders almost uncontrolled by banks, doing considerable damage to the forest growth along its margins and on the islands in mid-stream. When the greater curves swing across the valley, the river sometimes impinges against cut banks about 120 feet high, composed of gravel, sand, silt and clay, or against low rock terraces.

Hess River

The Hess river joins the Stewart from the southeast in a low basin formed by the junction of the two wide valleys of those streams. This river appears to be almost as large as the Stewart. Its drainage basin lies between those of the Macmillan and Lansing rivers, and extends to the Mackenzie river watershed, a distance of over 100 miles from its mouth. At the mouth of the Lansing river the Stewart turns to the northwest and flows across a basin-shaped depression which extends for a distance of about twenty miles on each side of the river, while Lansing river, coming from the northeast, occupies what appears to be the continuation of the Stewart valley.

Lansing River

Lansing river, about 200 feet wide at its mouth, has a very swift current throughout its entire course, and is not navigable. It heads in some high mountain groups to the east, and flows almost parallel to that portion of the Stewart above Beaver river.

The Lansing mountains, one of the most striking individual groups in the region, are situated south of the Lansing river and about fifteen miles east of the Stewart. These mountains rise abruptly from a wide basin; their summits are a group of rugged peaks, the highest of which rises to 7,400 feet above sea level or about 5,500 feet above the Stewart river.

At one and a quarter miles above Lansing river the Stewart emerges from a cañon with walls about 100 feet high. The length of the river course through this cañon is seven miles, the channel is tortuous and the current not much swifter than in the wider portion of the river below. It is easily ascended at low or medium stages of water.

Ladue River

The Ladue river which enters the Stewart from the west is an exceedingly crooked stream, flowing with a sluggish current in a wide valley. Its main branch heads in a mountain group twenty miles northwest of its mouth, but the river channel has a length of over 100 miles between those points.

Although the Ladue river flows in a wide flat-bottomed valley of slight grade for the greater part of its course, this valley is bordered by mountain groups rising abruptly to a height of from 2,500 to 3,000 feet above the river. In its lower course it flows across the basin which extends to Lansing river.

The Stewart bends sharply to a northeasterly direction at the north of the Ladue river and, about seven miles farther, the Beaver river enters from the west.

The Stewart and Beaver rivers join from opposite directions in a wide crescent-shaped valley which borders the southern edge of the watershed range. North of the junction of the two rivers the mountains rise about 3,500 feet above the valley bottom, but to the south the valley opens out into a wide depression containing a few rolling and wooded ridges.

Ten miles from the mouth of the Beaver, the Nadaleen, or Boswell river, enters the Stewart from the mountains to the northward. This is a clear rapid stream about 150 feet wide and two to three feet deep. The Stewart river at this point cuts through a heavy deposit of old river gravels overlain by boulder clay. This deposit which is from 75 to 100 feet thick extends across the valley and the material still acts to some extent as a dam, for below this point the river has a current of about six miles an hour, while above it there is scarcely any perceptible current at all, the river meandering between low mud banks and resembling a series of oxbow lakes for a distance of twenty-eight miles. About ten miles above this still water portion rock terraces from twenty to forty feet high occur for some distance up stream along the water edge. The valley becomes constricted at this locality, and the Tasin mountains rise abruptly on the south of the river where hitherto were only low ridges of a few hundred feet elevation. The northern front of the Tasin mountains extends along the valley for about twenty miles eastward. Mount Ortell, situated at their eastern extremity, is one of the prominent peaks of this region. It rises to a height of about 4,700 feet above the river or 7,000 feet above sea level. Beyond the Tasin mountains the valley becomes wide again, the rock terraces disappear, the river breaks up into a number of channels in a wide gravel flood plain and has a current of about twelve miles an hour. At a distance of 100 miles from the Beaver river the Stewart turns to the northeast and enters a narrower valley than formerly, situated between mountain groups. At a distance of twenty miles in a northerly direction from this point lies a lake about six miles long called by the Indians Ella-tsi-tuo; it is the head of one of the branches of Snake river flowing into the Peel. The Indians when journeying from the Stewart to the Mackenzie generally follow the Lansing valley and a valley which skirts the eastern end of the Tasin mountains; cross the Stewart to this lake, and thence to Fort Good Hope crossing the Arctic Red river en route. Time did not permit of an examination of the river beyond this point. It is said to extend about twenty miles farther east, and to have its source in a basin containing numerous small lakes and bordered by mountains. Lansing and Hess rivers, and a branch of the Gravel river which flows into the Mackenzie, also have their source in this locality.

On July 6 while passing the mouth of the Beaver river it was noticed that the Stewart discharges about twice as much water as the former. The water of the Stewart was very swift and muddy and crowded the clear water of the Beaver against the western bank. On July 22 the discharge of the Stewart had diminished while the Beaver maintained the same flow as formerly. At this date the Beaver river was 210 feet wide, its greatest depth about seven feet, with a current of four miles an hour. On August 18 water was at a low stage in both streams, and their discharge was about equal.

Beaver and Rackla Rivers

The Beaver river occupies the same valley as the Stewart, and has a northwesterly direction for a distance of about thirty miles in a straight line from the mouth, or forty-five miles following the windings of the river.

The valley and the river both turn at a right angle at this point, but at a distance of eight miles to the north they resume their former direction.

At a distance of twenty-five miles from the mouth of the Beaver, following the windings of the river, Rackla river, an important tributary, enters from the northeast. The river occupies a wide valley for about fifteen miles. The main valley then branches into three tributary valleys. The valley which enters from the west is a continuation of the upper Beaver valley, and is occupied by a series of lakes from two to three miles long. The other two valleys are occupied by branches of Rackla river, the one extending to the northeast being the continuation of the main valley. This valley leads with an easy grade to a low divide called Bonnet Plume pass, north of which is found the headwaters of the Wind river, which flows into the Peel. A short distance below the forks, Rackla river flows through a narrow twisted cañon and below this rock terraces occur at intervals along the stream for a distance of about five miles. In the upper valleys the streams meander over flood plains or in marshy ground through numbers of small lakes or ponds.

Above the mouth of Rackla river there is a stretch of fourteen miles of slack water, probably due to the fan of wash gravels which the Rackla carries down faster than the Beaver can remove it. At the square turn of the Beaver, twenty miles beyond the mouth of Rackla river, a small creek enters from the southwest and drains a wide valley containing a great number of small lakes. These lakes are nearly all connected by streams as far as the McQuesten lakes, a distance of about twenty miles from the Beaver river. By making a few short portages a canoe or small boat can be taken over this route to the McQuesten and thence to the Stewart river. Above the square turn the Beaver river is an exceedingly swift stream, and at low water is not navigable owing to the numerous channels over which the water is disturbed. Craine creek enters from the north about twenty-five miles farther. The valley of this stream was followed by Mr. Camsell of the Geological Survey on his journey to the Wind and Peel rivers.

The Beaver river was not examined beyond this point, but it appears to be fed by small streams issuing from the Ogilvie range. At some distance farther west these streams turn to the southwest and form the headwaters of one of the branches of the Klondike river.

Ogilvie Range

The Ogilvie range, which lies on the watershed between the Stewart and Peel rivers, has a width in this locality of about fifty miles, and extends from the valley of the Beaver river almost to the mouth of Little Wind river to the north. The northern edge of the Ogilvie range marks the termination of the mountainous region on the Peel River basin, and is followed by a low dissected plateau which lowers by successive steps to the Arctic coastal plain.

Flanking mountain groups extend southward and eastward from the Beaver river for a distance of forty miles. To the eastward the Ogilvie range is separated from the Selwyn range by the comparatively low divide between the Stewart and the Gravel rivers.

Over the whole extent of this elevated region the most general accordance of summit level would appear to occur at about 6,000 feet above sea level.

Of the several prominent peaks which rise above this level none are higher than 7,500 feet.

Yukon Plateau

To the southwest these mountain groups front upon the region known as the Yukon plateau which has a general elevation of 5,000 feet in this vicinity, sloping to about 4,000 feet at the Yukon basin.

The topographic relations of these mountains is extremely intricate and would require several seasons' observations over a more extended area in order to correlate the region physiographically with the provinces to the south and west.

Orographically the two principal mountain ranges are analogous to the Rocky Mountain system of British Columbia, as the lowlands bordering these mountains on the north and east correspond to the great plains east of the province.

The variation in the topography of the different mountain groups depends largely on the character and structure of the rock formations from which they are built. The highest portions of the Selwyn range being composed of tilted quartzites and agglomerates, or of granite, are as a rule bolder and more rugged than the crests of the southern face of the Ogilvie range which are built up principally of limestone.

The mountains south of the Beaver river, composed principally of crystalline schist, present a more regular and rounded outline, due no doubt to their earlier date of uplift and having been subjected to erosive agencies for a much longer period than either of the watershed ranges. The highest portion of these mountains is generally composed of intrusive diorite masses which have resisted weathering more successfully than the schist by which they are surrounded.

Although the principal valleys have a southwesterly direction, the drainage does not always select that course, but makes very wide detours at several points. Only a portion of the main drainage ways is in accord with the strike or trend of the rocks and the detours are generally made transverse or across the strike.

All the rock formations have jointage planes more or less well developed, along which the rock breaks down more readily. The direction of the dominant jointing and the dip of planes varies somewhat in the different formations.

In a rough way some of the interstream areas correspond in plan to the shape of one of the single blocks of rock that compose it.

Climate

The Stewart river generally opens and is clear of ice between May 10 and 15, and becomes frozen over by the end of October.

Although there is a high average rainfall in some seasons, the summers in this region are generally fine, the weather sometimes being hot.

During the summer of 1905 no frost occurred between May 25 and August 26, and the snow had almost entirely disappeared from the mountains on the first of August.

The long hours of daylight are favourable for abundant vegetation and the floors and slopes of the valleys are all well covered with a forest growth.

Trees

The principal forest trees are white and black spruce, balsam, poplar and birch. The limit to which trees grow on the mountain slopes varies from 1,800 feet to 2,800 feet above the river.

The white spruce is the most valuable tree and furnishes good timber for building and mining purposes. The best groves of this tree are found on the islands or on the alluvial flats along the river, but good specimens occur in scattered groups on the slopes to a height of 2,000 feet above the river in the lower valleys.

There is a marked deterioration both in the size and appearance of the spruce as the more northerly branches of the river are approached.

The balsam fir occurs only on the valley slopes mixed with spruce, beginning at an elevation of about 1,200 feet above the river, and continuing upward to the limit of trees. On the slopes of the Ogilvie range, however, the balsam disappears entirely, its northern limit in this area being about the forks of Rackla river.

The black pine (*Pinus Murrayana*) was observed only at one locality. On the south side of the Stewart, near the mouth of the Hess river, there is an extensive grove of this tree growing on a wide gravel terrace about 300 feet above the river. The trees are small, few of them exceeding nine inches in diameter.

Along the banks of the streams there is a thick growth of willow and alder, and for some distance above the tree line dwarf birch and moss cover the mountain ridges.

The greater portion of the forest growth on the slopes bordering the Stewart between the Frazer falls and Lansing river was destroyed by fire in the year 1898. This immense loss was due to the carelessness of some of the numerous gold seekers who entered the country during that year.

Vegetables and Fruit

At the mouth of Lansing river in a garden cultivated by Mr. Braine very fine vegetables are produced, including every variety grown in the neighbourhood of Dawson.

The small wild fruits such as the raspberry, blueberry, cranberry and red and black currants grow in great profusion and to a large size.

Game and Fish

The large game of this region includes bear of several species, wolves and wolverine, moose mountain caribou and mountain sheep. The principal animals trapped for fur are the lynx, fox, beaver, marten, otter and mink.

The rivers and lakes are well stocked with salmon-trout, whitefish, pike and grayling, and all the ordinary northern waterfowl are abundant.

The salmon on their way from the sea to the spawning grounds ascend the Stewart river in large numbers. Only the more vigorous fish are able to ascend the Frazer falls, but some are caught by the Indians at Lansing and have been seen as high as fifty miles up the Beaver river. At the mouth of Lansing river Messrs. Frank Braine and Percival Nash have established a trading post, and a small band of Indians live close by in cabins. Several Indians from Fort Good Hope on the Mackenzie river make regular journeys to this point, trapping and hunting along the route. A few white men make a regular business of trapping on the Hess river and its branches.

This region offers a great field for the sportsman and explorer, most of the country between the Stewart and Pelly headwaters and the Mackenzie being quite unknown.

Suitable boats or canoes can be poled or tracked on the main rivers well up into the watershed ranges. Several of the higher mountain groups offering sufficient inducements to the mountain climber and huntsman are situated within a day's journey from the river.

The scenery is very fine, the mountains gain impressiveness from their situation in low wide valleys, and their colouring is rich and varied. Some of the valley bottoms seen from a height have an extraordinary appearance suggesting a mosaic floor in which the pattern is worked out by the bright surfaces of the countless lakes and ponds and the narrow dark green land areas separating them.

General Geology

The geological information was gathered principally during the progress of the topographical work and although the areal distribution of the rocks was obtained in a general way it is of necessity incomplete and lacking in detail.

The important task of determining the sequence of the strata which are represented in a new area such as this is attended by many difficulties. Only by close and detailed studies over a region where the rocks have been much disturbed can the succession be definitely established, and this class of work has not yet begun in the Yukon territory. The work previously done has been on detached areas, the surveys being of a reconnaissance or exploratory character. The results thus obtained have never been correlated in a satisfactory manner as the apparent absence of fossils in some of the areas leaves only the unreliable connecting link of lithologic resemblance.

Geological Formations

A provisional classification for the purpose of description is given as follows, beginning with the oldest formation.

Pre-Devonian. The group of various schists, quartzites and crystalline limestones in the area south of the Beaver river.

Devonian. The limestones, ferruginous slates and quartzites of the Ogilvie range. An account of some fossils found in these rocks is given in Mr. Camsell's report on the Wind and Peel rivers.

Upper Palaeozoic. A large mass of white bedded crystalline limestone, forming the greater portion of a mountain group situated north of the Beaver and west of Rackla river.

Triassic. The rocks exposed along the Stewart river and bordering mountains, extending northward and eastward from the vicinity of Lansing river.

Concerning the rocks classed as Pre-Devonian it may be said that they possess the characteristics ascribed by Mr. McConnell to the group of rocks in the Klondike area which he calls the Nasina series. Rocks of this class outcrop at intervals along the lower portion of the Stewart river and they also form a considerable portion of the bedrock in the Duncan Creek district. Their age is undetermined, but in the area under consideration they are known to be older than Devonian, and may therefore be either lower Palæozoic or Pre-Cambrian.

They consist, like the Nasina series, of ancient siliceous, argillaceous and calcareous sediments now altered into quartzites, mica schist and crystalline limestone. With these are associated green schists which represent in most cases basic eruptive rocks, principally diorites and diabases, intruded along the bedding planes of the older formation and subsequently sheared and altered.

Quartz porphyries reduced to a similar condition also form a portion of this series.

Rocks of Devonian age appear to compose the greater portion of the Ogilvie range.

Similar rocks occur to the eastward along the Mackenzie river. In the latter region the rocks are practically undisturbed. Whether the continuity of the formation is preserved between these localities is not known.

The crystalline limestone, provisionally classed as Upper Palæozoic, rests unconformably on the crystalline schists, while it is apparently overlain by Triassic rocks. No fossils were found, and the contact with the Devonian rocks to the north was not seen. A similar rock mass occurs on the Macmillan river which was classed as Carboniferous from the evidence of some fossil remains found in that locality.

This occurrence also overlies crystalline schists unconformably and is followed by what are probably Mesozoic rocks.

The rocks grouped as Triassic are almost altogether of sedimentary origin. Thin bedding and diversity in the colour and composition of the beds are characteristic features. They have been greatly folded and crumpled in some localities, while in other places they are horizontal. Cleavage planes have been developed, and certain of the beds have undergone slight alteration during the processes of mountain building.

The rocks which underlie the eastern extremity of the area marked Triassic on the accompanying map sheet are chiefly made up of sandstones, grits, red slates, limestone and some volcanics, while toward the western end shaly argillites with thin quartzite and limestone beds prevail. Beds similar to the latter also occur in the section to the west.

The evidence gathered from the study of a few fossils found in the area while not conclusive, is in favour of referring at least a portion of the series to the Triassic.

A group of rocks similar in many respects to the above occurs along the Macmillan river forty or fifty miles to the south, but the black chert beds found in that area are absent in the Stewart River series.

Distribution of Rocks

At Frazer falls the river cuts across hard quartzose greenish schists, apparently crushed eruptives alternating with bands of softer green chloritic schist, and slightly schistose gray quartzite.

Between Nogold creek and Hess river the country rock on both sides of the valley consists of grayish quartzite in which are included some green schists similar to those seen at the falls.

The quartzite in this locality varies in the degree to which it has been altered. The least altered portions are composed of fine rounded interlocking quartz grains in thick well jointed beds which bear evidence of their sedimentary character in the form of ripple marks and false bedding. When fragments are broken off, the fresh surface shows occasional specks of mica, but a schistose structure is only poorly developed. On the other hand this rock grades into an extremely schistose phase consisting of alternate thin layers of silvery mica and elongated quartz grains.

Most of the intrusive rocks that are interbanded with the quartz schists have become so altered, and secondary minerals prevail to such an extent in their composition, that it is difficult to determine what the original source of the rock has been. In the field they are nearly always well defined owing to their usual dark green colour, different texture, and the fairly sharp dividing line between them and the quartzites, but in some cases they have undergone metamorphism along with their containing rocks to such a degree that it is impossible to separate them.

This group of schists is continuous with those of the Duncan Creek mining district immediately west of this area. They extend northward to the Beaver river, and are found to the south at a few places on the Macmillan river. Their eastern limit is unknown. They are of economic importance in this region as these metamorphic sediments, when associated with basic igneous intrusions, generally contain auriferous veins and appear to be the source of placer gold.

About nine miles below Lansing river the schists are replaced by a series of much younger rocks. These consist of dark, fine-grained, carbonaceous, and greenish argillites, slightly altered, with gray shales, dark, impure limestone, and narrow bands of sandstone almost hardened to quartzite.

The attitude of the beds at this locality is vertical, but at their southern edge is a bed of conglomerate containing rounded and elongated pebbles which appear to be derived from the schists farther south, but the contact with them was not found.

These rocks are exposed at intervals along the Stewart river as far as Nadaleen river; they form benches about thirty feet high in the vicinity of Lanzing river, and are the rock walls of the Seven-mile cañon. The prevailing strike of the rocks is east and west, and the attitudes of the beds vary from almost horizontal to vertical.

There is a good deal of minor crumpling and folding, and in some places small quartz veins and stringers intersect the beds.

About thirty miles above Nadaleen river several low rock terraces occur on the Stewart. The rocks of which they are composed consist of red and green slates, sandstones, grits or fine conglomerate, gray limestone, and shale. The sandstones and grits are very hard, and are composed mostly of quartz fragments with a siliceous cementing material.

Tasin Mountains

On the slopes of the Tasin mountains to the south of the river a good section is exposed, having a thickness of at least 3,500 feet. Beds similar to those seen near Lansing river are represented in the section. The uppermost beds are the sandstones, and these beds form the rugged mountain peaks of this group. The strike of the series is in general northwest and southeast in this locality. They appear to form an anticline, with the river flowing in the axis of the fold. The dips of the beds on the valley slopes are not steep as a rule, and the series are traversed by a system of jointing, the dominant planes of which trend in a northerly direction.

These rocks extend eastward for a considerable distance, as the red slate beds which are such a conspicuous member of the formation could be traced on the mountain slopes.

North of the Stewart river the mountains are built of heavily bedded limestone overlying yellow weathering ferruginous slates, and rocks of this character appear to form the greater portion of the Ogilvie range.

Rocks similar to those first seen in the vicinity of Lansing river extend some distance up the Beaver river and to a point a few miles above the forks of Rackla river. The contact in this locality is faulted, the limestones and associated rocks of the Ogilvie range being overthrust on the argillites. In a bed of dark, impure limestone associated with the argillites and quartzites near the forks of Rackla river, some fossil remains were found which have been identified by Dr. Whiteaves, who reports the following forms and refers them to the Triassic, but at the same time states that the evidence in favour of that view is by no means conclusive.

Pelecypoda

Some very imperfect remains of apparently four or five species, two of which have much the general appearance of *Monotis subcircularis* and *Halobia Lommelli*.

Cephalopoda

Fragment of a small Ammonitoid shell, apparently rather similar to Arpadites, but which shows no trace of any of the sutural lines. There seem to have been two longitudinal keels and three longitudinal grooves on the venter, and the transverse ribs are slightly flexuous.

The schistose series first mentioned cross the Beaver river a short distance above the mouth of the Rackla river. In this locality the schists vary in appearance from those to the south, being of different texture and not so massive. Thinly laminated quartz schist, soft greenish chloritic schist, and dark mica-schist, and some bands of gray crystalline limestone characterize this portion of the metamorphic series. Small bodies and stringers of quartz are numerous in the schists along the south side of the Beaver River valley.

Between Rackla and Beaver rivers and north of the schistose area is an isolated mountain group composed almost entirely of white crystalline limestone which is not invaded by any other rock masses. This limestone contains some siliceous beds and patches and a few thin seams of siderite, but no traces of fossil remains could be found.

Between the limestone and the schists lies a thick bed of breccia containing some large fragments of gray crystalline limestone and dark mica-schist.

Igneous Rocks

The unaltered igneous and volcanic rocks represented in this area occur in small detached and irregularly distributed masses.

The most important mass forms the central portion of the Lansing mountains, situated south of Lansing river and fifteen miles east of the Stewart.

The rock here consists of a coarse gray biotite-granite; it is strongly jointed and weathered into conspicuous peaks of a rugged character, which contrast strongly with the smoothly rounded contour of the adjacent sedimentary rocks through which it intrudes. Another small area of granite of similar composition occurs south of Ladue river on the eastern slopes of the Gustavus mountains. This mass has apparently been exposed to erosion for a considerable period and presents smooth, gently rounded surfaces.

Small bodies of granite of apparently the same composition as the above occur to the west and south of this area. As a rule they occur in the form of stocks or cores in a mountain group. The contact between the granite and the sedimentary rocks is generally clear and well defined, the latter rocks being considerably hardened for some distance from the granite.

The remains of a dome structure in the bedded rocks surrounding the unroofed granite stocks is sometimes apparent.

On the mountains east of the Beaver river and north of the Stewart a series of diabase dikes cuts through the gray argillites. These dikes were traced from this point in a westerly direction for a distance of twelve miles;

they cross the Nadaleen river and reappear on the mountain group north of the mouth of the Beaver river. On the mountains the dikes form the crests of the ridges, with almost perpendicular faces toward the south.

Small bosses and dikes of diorite frequently occur intruded in the schists on the mountains south of the Beaver river. The highest peaks of these mountain groups is often composed of diorite.

Andesite tuffs, ash-rocks and other volcanics are found in small quantities associated with the red slates and sandstones.

Glaciation

All the valleys in this region are floored with deposits of drift composed of a variety of materials and laid down under different conditions. The rivers have cut trenches in and removed vast quantities of these deposits, but the depth of material still remaining is unknown. Large patches of loose material still adhere to the valley slopes to a height of 1,500 feet above the river along its lower reaches, but in the upper valleys the drift mantle becomes thinner and does not appear to alter the pre-existing topography to any great extent.

Boulder clay or till, which is a direct ice deposit, occurs in large patches at several points along the Stewart river between Frazer falls and Nadaleen river, but none was observed above this point. The exposures of boulder clay, where cut into by the river, are at least 100 feet in thickness and present the usual steep faces with the upper portion carved into pinnacles and knots.

At the few points where the bottom of the thick sheets of boulder clay was observed they rest on low bed-rock benches, but on other points thin sheets of boulder clay overlie or are interstratified with sands or gravel, indicating reinvasions of the ice after the general withdrawal. Following the boulder clay on the downstream side there are generally found non-coherent and confused deposits consisting of boulders, gravel, sand and clay which appear to be morainal overwash.

Between these accumulations which may be terminal moraines, are found deposits of more or less evenly bedded materials varying in coarseness from fine silts to beds or layers composed of boulders.

Deposits of this character form the greater portion of the drift along the rivers, and on Ladue river they have a thickness of at least 250 feet.

No boulder clay was observed on the Ladue river or in the wide valley between the McQuesten lakes and the Beaver river, the latter valley being floored with fine river sand.

A thick deposit of plastic blue clay without pebbles occurs in the middle of the wide valley of the Stewart about thirty miles above Frazer falls, and a similar deposit was found underlying sand and gravel beds opposite the mouth of Hess river.

Some of the materials of the drift have been transported to points far distant from their source. The hematite and jaspilite pebbles which are caught in such abundance in the sluice boxes on all the creeks of the Duncan Creek mining district have their source somewhere between the headwaters of Rackla and Wind rivers. In this case the drift has travelled for a distance of 100 miles or more. Pebbles from other rocks are known to have been borne over great distances, although the evidence is not always so unmistakable as in the case of the hematite pebbles, when attributing the distribution of certain portions of the drift to glacial movements.

Judging by the character of the drift deposits which have been described, and from observations made in other portions of the Yukon territory, it is evident that running water, still water and ice have all contributed directly towards their accumulation.

During the glacial epoch glaciers descended the Stewart valley from the elevated region around its upper waters. At the period of maximum accumulation the valleys were all filled with moving ice and only the upper portions of the higher mountain groups were uncovered.

The general level of the ice in that area was about 5,000 feet above sea level. In the vicinity of Frazer falls the ice reached a level of 4,000 feet and the westerly limit of glaciation occurs near the mouth of the McQuesten river. Although the ice sheet was thick enough to over-ride several of the ridges and lower mountains its movement appears to have been controlled to some extent by the topography, for at the few places where glacial groovings and striae were observed they indicated a movement in the direction of the principal valley.

The events of the glacial period have affected the topography of the Stewart River basin both by erosion and deposition. The hills were smoothed and rounded in outline and the valleys were widened by the removal of rock waste from their slopes, and this material was transported and irregularly deposited at certain localities where the margin of the ice sheet was constant for some length of time during its withdrawal.

In the higher mountain groups glacial activity continued and sent down ice through side valleys after the main valley glaciers had retreated. The river at several points has cut through mounds of unsorted drift which were probably the terminal moraines of these local glaciers. These local glaciers extending across the main valleys acted as obstructions to the drainage, and extensive lakes were formed into which the glacial streams washed their burden of debris, the coarser material being deposited near the point of discharge, and the finer materials such as rock flour being carried farther before deposition.

Economic Geology

That portion of the region which is best worthy of the attention of the miner in search of placer gold is the area situated east of Mayo lake and south of the Beaver river.

This area is underlain principally by schists of various origin and character which are intruded in places by igneous rocks, such as granite, diorite and diabase. The bedrock of all the productive placer ground in the Yukon territory is of a similar character to the above.

On the accompanying map sheet a portion of the Duncan Creek district is shown and the geological relations between it and the new area to the east are laid down.

Colours of gold were obtained in the gravels of many of the small streams flowing over this area, but whether there is sufficient gold to pay for mining can only be determined by the usual process of reaching bedrock.

Physical conditions on the Ladue river render it a singularly uninviting locality for the prospector. The river itself flows with a sluggish current in a wide flat-bottomed valley containing a great depth of mud, sand and fine gravel. Most of its tributary streams are small torrents heading in high mountain groups. South of the Ladue river in the area through which Rupe, Edwards and Nelson creeks flow, conditions appear to be more favourable for mining, for although some of these streams head in high domes, they mostly flow with easy grades between low, well-rounded ridges.

In the area between Hess river and Lansing river east of the Stewart at least four creeks flowing into those streams are known to yield coarse gold. This portion was not examined by the writer, but on Congdon creek, which comes into the Stewart from the east about six miles below Lansing, good prospects were obtained by one of the party in the surface gravels.

The same difficulties which attend mining in the Duncan district, such as underground water and large boulders in the creek bottom, may be expected in these areas.

Above the mouth of Mayo river the gravel bars on the Stewart, although slightly auriferous, do not yield gold in paying quantities. Beyond the mouth of the Beaver river the bars do not appear to be auriferous. The same may be said of the Beaver, and although fine gold was said to have been found in 1898 on the bars of Rackla river, its principal tributary, no colours could be obtained by the writer's party on that stream, but on a small stream nearly opposite the mouth of Rackla river coarse gold was obtained in the surface gravels.

No gold-bearing quartz has up to the present been discovered in this region. Small bodies and stringers of vein quartz are of common occurrence in the area of schistose rocks described above, but no trace of gold-bearing rock was seen on that portion of the area traversed.

A large body of quartz forming low rugged ridges crosses the Stewart valley about eighteen miles below Lansing river. Another large body of quartz occurs on Rackla river, below the forks. These bodies are apparently barren of any mineralization.

The existence of large bodies of iron ore at the headwaters of the Wind and Bonnet Plume rivers has been known for some years. Outcrops of this ore were seen by a few of the gold-seekers who journeyed to the Yukon by this route. The drift from these bodies is widespread on the basin of both the Peel and Stewart rivers, being found all along the tributaries of the latter as far as the mouth of the McQuesten. In these localities the drift from the iron beds is only found during the processes of mining, as on account of its weight it sinks to bedrock.

On Rackla river, however, which apparently heads near the source of the iron, large fragments are found on the surface.

The pebbles wherever found show an exceedingly fine-grained very compact hematite, some of which also contain thin bands of red jaspilite. Small boulders showing bands of pure ore four or five inches thick were found near the forks of Rackla river.

The presence of these ore bodies is an interesting fact, but in this region they are very unlikely to be numbered among the economic mineral resources of the territory from a commercial point of view.

THE PEEL RIVER AND TRIBUTARIES

by Charles Camsell

Introduction

The field work assigned to me for the season of 1905 embraced a geologic and topographic reconnaissance of the Peel river in the extreme northwestern portion of the Dominion. Owing to the shortness of the season in that part, and the difficulty and length of time required to get in and out of the region, an early start from Ottawa was very necessary. In accordance therefore, with instructions received from Dr. Bell, I left Ottawa about the middle of March for Winnipeg. Here some supplies were purchased and shipped by the Hudson's Bay Company to meet me at Fort McPherson in August, and later I proceeded to Dawson, where I arrived on the 14th of April.

At Dawson the interval between the closing of winter travel and the opening of navigation on the streams was consumed in the testing and correction of instruments, and in visiting and examining the placer mines of the Klondike creeks; and during this period we were much indebted to Mr. J. B. Tyrrell for his kindness and hospitality in allowing us the use of his house. To Major Z. T. Wood also, Commandant of the North-west Mounted Police in the Yukon, are my thanks due for his kindly assistance in the selection of canoemen and the loan of a canoe.

On May 22, the party, consisting of six men and three canoes, left Dawson by the SS. *Prospector* for Frazer falls on the Stewart river. Four days were consumed in reaching this point. Another delay, occasioned by an early rise of water in the Stewart river, prevented us from moving until June 5. When we began our journey at this date, it was only with the greatest difficulty and some danger that any progress could be made. With the water fifteen or twenty feet higher than its normal stage the velocity of the current is greatly increased, quantities of driftwood are being carried down stream and in many places the banks are completely submerged. Under these conditions we were eight days in getting as far as Lansing river, a distance of eighty miles.

Above this river the water was at a much better stage and the travelling was easier, until we came within twenty-five miles of the mouth of Braine creek. In this portion of the Beaver river, a northern tributary of the Stewart, the stream is split up into several channels and is filled with gravel bars, while the grade is greatly increased, so that considerable difficulties were again encountered in making progress. At the mouth of Braine creek the actual survey commenced, though a track survey had been carried up from Williams' cabin at the cañon seven miles below, to connect with Mr. Keele's survey of the lower part of the Beaver river.

Routes Selected

It was my original intention on leaving Ottawa to follow identically the same route across the mountains which was taken by the prospectors in 1899, but I was dissuaded from this on reaching Dawson by many of those who came through the Bonnet Plume pass. These men stated that on account of the difficulties of this particular route, any other would be preferable. I could not learn that any one, at any time, whether white man or Indian, had ever taken a canoe across into the Peel River watershed by any other route than the Bonnet Plume pass. But I did learn that the Indians had come across from the Wind river to the Beaver river through a pass that was said to be very much lower than the Bonnet Plume. It was finally decided if possible to find this winter route and follow it.

On our way up to the Stewart river, we met Mr. Braine of Lansing creek, and from him we obtained the necessary information as to how to find the pass to the Wind river, for he himself had been through a part of it the winter before. It is sufficient to say here that the Braine pass through the mountains, though an easy winter route, is not a feasible one for canoes. Though we went through at a time when the water in Braine creek was probably at its best stage, yet we had to portage almost the entire load for fifteen and a half miles, and the canoes themselves for three and a half miles.

A micrometer and compass survey was carried from the mouth of Braine creek through Braine pass, and down Nash creek to the Wind river, a distance of thirty miles.

From the mouth of Nash creek to the Peel river the course of the stream is almost true north, so that to save time a careful track survey, checked by frequent observations for latitude, was all that was made. The distance is approximately 100 miles.

We reached the Peel river on the 13th of July, and from this point a micrometer survey was recommenced and carried down the stream to a point 98 miles below Fort McPherson, where the western branch of the river first joins Mackenzie waters, and from this point back to Fort McPherson by the central branch of the Peel river. The survey of this portion was completed on the 11th of August, and on the 15th the return journey to Dawson was begun.

Returning, the route followed was that by the Rat river through McDougal pass and into the Bell and Porcupine rivers, the same as had been taken by Mr. W. Ogilvie in 1887. A small portion of new work was done here in surveying the central and largest outlet of the Rat river, the south branch, which was done by Mr. Ogilvie, being impassible excepting in the spring. The Rat river empties by three branches into Peel River waters, but the northern branch is an inconsiderable stream and only navigable in high water, so that no attempt was made to survey it. In the ascent of Rat river, we were particularly fortunate in having a great deal of rain and snow, which, though making the travelling very disagreeable, raised the level of the water sufficiently in the stream to allow of comparatively easy canoeing. The same conditions allowed us to get our canoes within six hundred yards of navigable waters on the other side of the divide, so that a portage of that length was all that was necessary. Had we been a week or two earlier, or a few days later, we would probably have been compelled to make a portage of three or four miles in length.

The Porcupine river was followed down to its junction with the Yukon at Fort Yukon, where we arrived on September 8, the actual travelling time from Fort Macpherson to Fort Yukon being twenty days. A track survey was carried all the way from Fort McPherson to the boundary line of Alaska just below Rampart House, where it was closed.

After a delay of five days at Fort Yukon, we caught one of the Northern Commercial Company's fast steamers plying between Dawson and St. Michaels, and arrived in Dawson on the 17th of September.

Previous Explorations

The first mention we have of the Peel river is by Sir John Franklin in his second voyage to the Arctic sea 1825-1828. On returning from this expedition, and while ascending the Mackenzie river a short distance above its mouth, he was led into the stream which he at first mistook for a branch of the Mackenzie. He ascended it for some considerable distance under this impression before he found out that it was an entirely different stream. He called it the Peel river in honour of Sir Robert Peel, and the favourable account he gave of the stream, and more particularly of its fur-bearing animals, attracted the attention of the Hudson's Bay Company and shortly after induced them to send an exploration party under Mr. Bell to make an examination of the river preparatory to establishing a trading post on it.

In the summer of 1839, Mr. Bell explored the river to the head of the Snake River branch, thinking this was the main stream, and the following year Fort McPherson was established at the head of the delta. During the winter of 1840-41 Mr. A. K. Isbister, also an officer in the employ of the Hudson's Bay Company, made a survey and sketch from his own and Mr. Bell's observations of the stream. This he published, along with an account of the topography and geology of the region, in Volume XV, 1845, of the Royal Geographical Journal.

In the summer of 1893, the late Count V. E. de Sainville, who was then living at Fort McPherson, with one canoe and two Indians made a very good survey and map of the stream as far as the mouth of the Wind river. As a rule the natives in going up to the Wind river, leave their canoes about 75 miles above the Fort and walk straight across country to the mouth of Wind river, thus avoiding the swift water in the river and cutting off the big bend that it makes. Count de Sainville, however, followed the course of the stream the whole way up to the Bonnet Plume river, the journey occupying two weeks. At the mouth of this stream, he left his canoe and walked up the river bank about twenty-five miles, from which point he cut across to the Wind river. This he followed down to its junction with the Peel river and back again to his canoe. On his map he gives his distances, elevations, and latitudes. He also mentions the occurrence of hot springs at the mouth of the Bonnet Plume river, at which ducks and geese were said to remain all winter. He notes also the existence, between the Bonnet Plume and the Wind rivers, of lignite beds which were burning at the time, and according to Indian report had been for years before. These beds are still burning.

Early Prospectors

For three or four years after the placer diggings were first discovered on the Klondike river, prospectors crowded into Dawson by every possible route, and some of those who went by the Mackenzie river found their way across the mountains by the Peel River route which led them through the Bonnet Plume pass into the waters of the Stewart river. In the fall of 1898 about 90 persons who followed this route found themselves compelled to winter on the Peel river. Most of them managed to get as far up as the mouth of the Wind river, where they built their cabins and spent the winter. A cluster of deserted cabins, which stand a few miles up the Wind river from its mouth, was called by them Wind city. During the winter they hauled their outfits and supplies to the head of the Wind river and through the Bonnet Plume pass, and thence down the Hell or Rackla river to a point about twelve miles from the Beaver river, which they called Spring camp. Here on the opening of navigation, they built boats or rafts and proceeded down the Stewart river to Dawson. A few of them remained on the north side of the divide until the rivers opened up, and then took their canoes across the pass and floated down the Rackla river. Mr. Patterson of Dawson was one of the latter, and from him I got a great deal of information relative to the Bonnet Plume pass and the head of the Wind river. The pass he reports to be wide and flat, with an almost imperceptible slope to the waters of the Wind on the one side and those of the Stewart on the other. In fact one of the streams at the summit could, with very little trouble, be diverted so that it would flow to either side. He himself simply dragged his canoe through the marsh on the summit, and never had to carry it at all. He estimated the summit of the pass to be 3,500 feet above sea level.

About five years ago a couple of prospectors crossed the Peel-Yukon divide at the head of the Twelve-mile or Chandindu river, and descended the whole length of the Peel river to Fort McPherson on a raft, being the first white men to make the trip, but as these men were lost, and strange to say, thought themselves on the Stewart they made no sketch of the river, and only discovered their whereabouts when they landed at Fort McPherson.

In December, 1902, a small patrol of North-west Mounted Police left Dawson with dog teams, and crossing over the divide at the head of the Twelve-mile river, got into Peel River waters at the Blackstone river. They crossed to the Hart river and from thence to the Little Wind river and descended that to the Big Wind. From here they followed our own route to Fort McPherson, except that they cut across the big bend in the Peel from the Bonnet Plume river to Trail creek.

Detailed Description of Routes

Braine Creek

Braine creek is a typical mountain stream, never in any part navigable for canoes. Rising in two small mountain glaciers on the flanks of one of the highest peaks in the region, it flows first in an easterly direction for two and a half miles, when it is joined by a branch of almost equal volume from the west. The combined streams then turn sharply to the southwest and, cutting almost directly across the strike of the rocks, join the Beaver river about fourteen miles below.

The stream occupies in its lower portion a broad U-shaped valley, sometimes a mile in width, with the bordering mountains rising to a height of 3,000 feet on either side. In the upper portion this width sometimes contracts to a quarter of a mile and its character is more V-shaped. The grade is always exceedingly steep, and the volume of water is never very great; wherever it is confined to a single channel, the latter is sufficient to float a lightly-laden canoe, but as the tendency of the water is to spread out into several different channels, the opportunities for real canoeing are rare.

Two cañons occur between the mouth and the forks of the stream. The lower one, at a distance of two miles from the Beaver river, is deep, narrow, and about two-thirds of a mile in length, around which a portage of half a mile has to be made. The stream here contracts to a width of twenty feet, and the walls are 150 feet high and almost vertical. The cañon lies at the entrance of the creek to the valley of the Beaver river, and is cut in a bed of dark, massive limestone which strikes at right angles to the course of the stream, or parallel to the Beaver river. It is the result of former glacial conditions, and has been formed since the ice retreated from the valley of the Beaver river. Evidences of a terminal moraine occur at the cañon, and the valley of Braine creek approaches a hanging valley in character.

The second cañon lies four and half miles above the first. This is caused by an eruptive mass of diabase, which cuts across and obstructs the valley of the creek. Its length is about 300 yards and the drop in it about twenty-five feet.

Immediately above each of these cañons the bed of the stream expands to a width of two-thirds of a mile, and occupies a greater part of the valley. These expansions in the beginning of July were still almost entirely filled with sheets of ice, varying in thickness up to ten feet, and through these the water has cut narrow winding channels. As the course of the stream is continually shifting, the water melts and wears away the ice at the base of the ice sheet, until it overhangs to such an extent that it is not able to support its own weight, and it falls with a splash. The result is that the course of the stream is diverted to the opposite side, where the same action is repeated.

Wherever the ice has melted away from the surface of the gravel, it has left on the pebbles a white deposit of carbonate, originally derived from the limestone bed over which the stream flows. This was first carried in solution in the water, then precipitated by freezing, and finally left as a residue on the melting of the ice. These large ice sheets, which cover several acres and are sometimes a mile in length, are formed in the winter time by the constant overflowing of the water. A great many of the small tributaries of Braine creek are fed from springs in the limestone, and these probably maintain a continuous outflow throughout the year, so that even in the coldest weather there must be a certain quantity of water flowing down the creek, thus accounting for the formation of the ice sheets. These latter attain a considerable thickness, but whether the accumulation of ice during the winter is balanced by a proportionate thawing during the summer was not determined; it is, however, probable that, except for a few isolated and shaded patches, the thawing action of the summer predominates, and all or most of the ice disappears.

The valley, where occupied by these glaciers, is bordered on either side by benches of clay and gravel. A bench of this character extends from the lower cañon right up to the second cañon, a distance of four and a half miles. It appears to be almost, if not absolutely level. At the lower cañon the top of the bench is 200 feet above the bed of the stream, and gradually approaching nearer to the level of the water as it ascends the valley, it disappears entirely at the second cañon. If this bench is actually level, it makes the grade of this part of the stream about fifty feet to the mile, inclusive of the two cañons.

At the second cañon there is an abrupt rise in the floor of the valley, caused by the aforementioned dike of diabase. This rise is slightly increased by a heavy deposit on the dike of glacial detritus irregularly distributed, which is apparently another terminal moraine similar to that at the lower cañon. A faint outline of another bench, similar to the well-defined one below, can be traced on the sides of the valley above the second cañon.

Above the second cañon, as below, expansions of the stream are occupied by sheets of ice; but the valley soon contracts to a width of a quarter of a mile, in which the water is necessarily more confined, allowing no room for the accumulation of ice. Here, rising abruptly from the water's edge, are steep talus slopes, on some of which banks of snow lie quite close to the stream.

Two miles below the forks of the creek, to which point the canoes were dragged, the character of the valley suddenly changes. The stream is here confined to one channel, the grade is not so steep, while the valley, widening to half a mile, is occupied by several small, marshy ponds. This portion is entirely devoid of any timber. Along the edge of the stream and ponds is a light growth of alders and willows, which is shortly replaced on the sides of the valley by bare rocky slopes of limestone talus. Only at the forks again does any spruce occur.

At the forks of Braine creek the valley divides, forming two passes, each of which brings one in a few miles into Peel River waters. One pass runs off to the northwest, and the other to the east. Camp was pitched here for a few days while the two passes were thoroughly explored, and the easier one selected for the portage. Though the eastern pass is 200 feet lower than the northwestern, the latter was the one chosen, because it brought us into a much larger and more navigable stream than the other. The eastern pass is the more direct route to the Wind river, and is the one that travellers would be more likely to take in the winter time.

The summit of the eastern pass is 150 feet above the level of the forks of Braine creek. The valley is very wide and open. A scrubby growth of willows and alders fills the bottom of the valley, and the sides are fringed with a scattered growth of black spruce which extends a very short distance up the slopes of the bordering mountains. The tops of the mountains are usually about 2,700 feet above the bottom of the valley and consist of massive limestones, interbanded with layers of black slate and shaly limestone. The divide lies about two miles from the forks of Braine creek. Here a small creek heads, and after flowing for two miles through the broad flat valley, passing in its course through three or four small marshy lakes, joins a larger stream coming from the south; the combined streams then flowing in an easterly direction, enter the valley of the Wind river about five miles below. This stream, however, does not, on entering the Wind River valley, unite immediately with the Wind river; but, running parallel with it and in the same wide valley for several miles, connects at almost the same point as Nash creek. In fact, some of the water of Nash creek flows into this creek before its junction with the Wind river. This stream, however, did not appear to be navigable for canoes, and for that reason this eastern pass was not selected.

The floor of the valley is covered with a thick deposit of glacial detritus irregularly distributed throughout its length and breadth. This is either piled up in scattered mounds, or else depressions have been left which are now filled with water. Numerous alluvial fans formed from the wash of the higher slopes project out from the base of the hills on either side.

In the northwestern pass the summit is 350 feet above the forks of Braine creek, and 400 feet above Nash creek, and is situated about half-way between the two points. The distance which the canoes had to be carried was three and a half miles. This pass is a part of the same structural valley that the eastern pass occupies, and a straight line drawn at right angles to the course of the Braine valley below the forks would cut both passes. Like the eastern pass, the northwestern is wide and open, and by following caribou trails through the low scrub the necessity of cutting a trail across was avoided until we got on to the lower flats of Nash creek, where a heavy growth of spruce and poplar was encountered.

On the lower part of Braine creek a few indications of the former presence of travellers or hunters were noted but, towards the head, none at all. In the wooded flats of Nash creek I noticed several rotting tree stumps that had been cut probably forty or fifty years ago; but nowhere were there any recent signs of human presence.

Topography and Geology

Braine Creek

Topographically the country between the Beaver river and Wind river is one of rather rugged relief. This is the back-bone of the great Rocky Mountain system, which here trends northwest and southeast, swinging slightly from its almost north and south trend farther south. This particular section is called the Ogilvie range. Few prominent peaks occur, and from the tops of any of them a general accordance of level can be noticed. The summit of Braine pass is estimated at about 3,400 feet, and the elevation of the highest peaks in the neighbourhood at 6,800. The general level of the whole range is somewhat lower than that farther south, though considerably higher than the elevation of the range to the west of Fort McPherson. The total discordance of vertical relief is about 3,000 feet. Few peaks exceed this.

The great wide valleys are longitudinal valleys coinciding with the strike of the rocks, and these are joined by narrower and shorter transverse valleys. The Beaver river occupies one of the former, as also the upper parts of Nash creek and the Wind river. These are roughly parallel to each other, though the lower part of the Wind River valley lies at a sharp angle to them.

The region during the glacial period was not covered by a large continental ice sheet, but the valleys alone were filled to a depth of 1,000 to 1,500 feet with valley glaciers, which apparently moved along the present grade of the stream. Evidence of glaciation can be traced to a height of about 4,500 feet above sea level, so that about 2,000 to 2,500 feet of the highest peaks protruded through the ice. The limit of glaciation corresponds fairly closely to the tree line, and is well shown by the rounded and graded appearance of the slopes and shoulders, above which the outline is more rugged and broken.

In the gradual retreat of the glacier up the valley of Braine creek, it evidently halted at each of the cañons a sufficiently long time to allow of the formation of extensive terminal moraines. On the disappearance of these glaciers, the valleys, both of Braine and Nash creeks, were filled to a depth of from fifty to a hundred and fifty feet with a heavy deposit of boulders, gravel and clay, the ground moraine of the valley glaciers, which was later subjected to deep dissection by the present streams, resulting in the region taking on its present topographic form.

At present only a few small cirque glaciers exist, and these only on the northern flanks of the mountains, where they are protected from exposure to the rays of the sun. The small glaciers in the bed of Braine creek have been already referred to. None of these were seen on Nash creek, though several of them occur in the valley of the Wind river.

A section across the summit from the Beaver river to the Wind shows a series of closely folded and sometimes faulted limestones and slates with some quartzites and conglomerate. Cutting these are some diabase dikes and intrusive rocks. The succession in descending order is somewhat as follows:—Massive dove coloured limestone becoming shaly at the base; bands of black slate; massive granular limestone containing fossils; ferruginous slates weathering red, and black weathering conglomerate at the base. Remnants of a coarsely crystalline quartzite at the top of the series sometimes form the peaks of the higher mountains. These strike as a rule from west to northwest, and dip at various angles forming a succession of synclines and anticlines. Many of the streams have cut out their valleys in the anticlines with the result that the sides of these valleys often present precipitous slopes and cliffs to the streams.

The great valley at the head of Braine creek, which forms the pass across to the Wind river, is apparently a great line of weakness, which has resulted in an overthrust fault, thus bringing up the underlying ferruginous slates to the surface. Along this line of weakness the slate has been much folded and contorted, and the limestone shows evidence of metamorphism in being converted into a white marble, which cleaves easily into the large rhombs of calcite. Another fault also occurs a few miles above the mouth of Braine creek, but its character is indefinite, and, unlike the other, is not marked by any great valley, though the metamorphic action resultant on the fault is plainly noticeable.

As we approach the Wind river, the upper limestones are replaced by the ferruginous slates, being brought up to form the summits of the mountains by a wide anticline. These dip down again to form the wide structural valley of the Wind river. The appearance of the ferruginous slates is a noticeable feature in the topography of the region, for the slopes take on a dull reddish colour due to the oxidation of the iron in the slates.

With the exception of some limonite in the rocks at the pass, no indications of economic minerals occur. While a few small colours of gold were obtained on the Beaver, these disappear entirely on Braine and Nash creeks.

Nash Creek

Some fossil corals and brachiopods collected from the limestone at the summit and lower down Braine creek have been identified by Dr. Whiteaves as Devonian forms.

Nash creek is considerably larger and longer than Braine creek. From the top of a mountain, 2,700 feet above the stream, a good view of the valley was obtained; it has a length of about 25 miles, and rises in a large lake two or three miles long. The general direction of this valley is almost true east and west in its lower part, bending slightly to the north above the portage. Its valley is wide and U-shaped and increases in width near the head of the creek, where several lakes occur besides the large one in which the stream rises. From the north end of the portage trail to the junction with the Wind river is a distance of twelve miles. It enters the Wind valley, however, at nine miles from the portage and flows in it for three miles before joining its waters with those of the Wind river. One mile above the portage the stream forks, the smaller branch also rising in a lake about five miles beyond. The two branches each occupy, for several miles, a part of the same wide valley, and are only separated from each other by a long, narrow, isolated ridge 1,500 feet above the stream at its highest point. The upper part of the Nash valley lies parallel with the Beaver valley and, like the latter, coincides with the strike of the rocks. A straight line drawn through the upper part of the Nash valley and continued southeast would run directly through the two passes at the head of Braine creek, so that Braine pass is practically the continuation of the Nash valley, while the Nash valley below this is tributary to it. The grade of Nash creek is very steep, and though only one short cañon occurs, the rest of the stream is exceedingly swift, shallow and full of gravel bars. It is often bordered by cut banks of consolidated clay and gravel of glacial origin, which have a height of 100 feet and more. In two or three places great snowslides had occurred, and in one of these the water had cut a narrow channel between walls of snow twenty-five feet high.

Though on the northern slope of the divide, the water of Nash creek is about four degrees warmer than that of Braine creek, due, no doubt, to the large lakes in which Nash creek rises. The vegetation too is slightly different in character. Balsam poplar grows in abundance on the flats of Nash creek, while none was seen on Braine creek. Arctic poppies in great profusion were seen on the northern slope of the divide.

Wind River

On information obtained from some of the prospectors who crossed by the Bonnet Plume pass in 1899, I estimated that we reached the Wind river at a point about twenty-five miles below that pass. According to estimates made with a cyclometer in winter time by these prospectors, the distance from Peel river to the Bonnet Plume pass is 132 miles. My own estimate of the distance from Nash creek to the Peel river is about 100 miles.

The Wind river is so called by the Indians of that region because of the furious gales that are constantly blowing down its valley.

The valley occupied by the Wind river is broad and U-shaped, timbered in some parts by spruce and poplar, but totally bare in others. In this the Wind river flows in a broad, shallow bed sometimes half a mile wide. Where confined to one channel the breadth of the stream, before its junction with Nash creek, is 100 feet, and its water is beautifully clear and blue.

Looking up the Wind river from the mouth of Nash creek, the valley appears to widen slightly and become shallower, and the bordering mountains have more gentle slopes and are relatively lower. It appears to be well timbered and the occasional gleam of sheets of ice can be seen in it.

Directly opposite the mouth of Nash creek a broad tributary joins the Wind river from the east. This appears to take its rise in a large basin-shaped hollow at the foot of some high, jagged snow-capped mountains, which rise to a height of over 3,500 feet above the river.

From Nash creek to where the Wind river breaks abruptly through the mountains is a distance of forty miles, and for this distance the course of the river is almost true north. The stream occupies a synclinal valley 3,000 feet deep, over which the water spreads in numerous channels, mostly too shallow to float a canoe.

In several expansions of the river bed large sheets of ice were still remaining at the beginning of July, similar to those occurring on Braine creek. These, however, would all disappear long before the end of the summer.

Where confined to one channel, the water is deep, and runs at a rate of from four to eight miles an hour. The timber here consists almost entirely of a small and stunted variety of spruce, which fringes the valley at the base of the slopes, and extends a few hundred feet up them. Cut banks of stratified sands and gravels are common, and alluvial fans occur at the entrance of nearly all the small tributaries.

The only stream of any importance entering the Wind river in its mountain section is the Bear river. This enters from the east at a point about twenty-five miles below Nash creek. It debouches into the Wind by several channels which spread over a delta plain three-quarters of a mile wide, so that it is difficult to estimate its volume. It is not easily navigable for canoes, though according to Indian report, it is occasionally used by the natives as a route to and from the Bonnet Plume river, with which it is connected by a number of small lakes and portages. Indian report is also responsible for a story of the existence of an active volcano in the mountains towards the head of Bear river; but judging by the nature of the rocks this is highly improbable.

On leaving the mountains the river emerges at once on to a rolling country of foothills, afterwards changing to a perfectly level wooded plateau which extends northward practically to the delta of the Mackenzie river. To the right the mountains extend away far to the east, presenting a rather abrupt face to the lower country, and unbroken by any great valleys except that of the Bonnet Plume river. Westward they stretch away to the Little Wind river, beyond which they swing round to the north, and cross the Peel river near the mouth of the Hart river, thus forming a great semi-circular basin enclosing the lower parts of the Wind and Bonnet Plume rivers, and in which a few isolated outliers of the mountains break the monotonous level of the region, and rise to a height of about 2,000 feet.

The plateau itself is well wooded with small spruce and tamarack, and dotted here and there with numerous lakes. The surface is covered with a deep growth of sphagnum, making it a huge muskeg typical of the Mackenzie valley.

As it leaves the mountains the bed of the stream quickly expands to a width of almost a mile, and for three miles the water spreads all over this in numerous shallow channels. Large sheets of ice were yet remaining on the bars, and on these several caribou were seen.

Beyond this expansion the stream becomes more confined, and flows between steep banks 150 feet in height, composed of horizontal or gently inclined sandstone beds, until it is joined by the Little Wind river at a distance of eighteen miles below. Two miles above the Little Wind river the valley gradually contracts and approaches more to the nature of a cañon, the stream is swifter and bordered by high cliffs of limestone. The Illtyd range of mountains, the highest point of which rises 2,600 feet above the river, here crosses the river diagonally striking a few degrees west of north.

The Little Wind river was not explored, though from the tops of two of the hills of the Illtyd range its course was sketched in for a distance of twenty miles. It joins the Wind river from the west, emptying a volume of water about two-thirds as large as the main stream. Its water is much dirtier, and the temperature one degree lower (49°). It emerges from the mountains twenty miles above its mouth, and flows with a swift current in a wide valley cut into the rolling plateau. The banks are from fifty to a hundred feet high, and the stream is divided by gravel bars into several channels. It forks just at the edge of the mountains, and it was down the west branch that the North-west Mounted Police patrol travelled in January, 1902, on their way to Fort McPherson.

Shortly below its junction with the Little Wind river the bed of the main stream again expands, and down to within a mile of its junction with the Peel river it keeps an average width of half a mile. This, however, is taken up largely with willow islands and gravel bars, through which the stream has cut numerous small channels.

The valley here is incised to a depth of sixty feet in the plateau, and the bedrock is only rarely exposed where the water cuts into the banks of the valley. The adjoining country is thickly wooded with spruce and tamarack and some birch, and the prevailing feature is the typical northern muskeg.

Hungry Creek

The only stream of any consequence entering below the Little Wind river is Hungry creek. This enters from the west at a point twenty-five miles above the Peel river. It debouches by several channels over a flood plain a quarter of a mile wide. Its bed is filled with gravel bars, and its banks are low and composed of clay and gravel. It rises in a large lake about fifteen miles up, and flows from this with an easy grade through the low rolling country. Its water has a brownish colour suggesting its origin in muskeg lakes.

During the autumn and winter of 1898 Hungry creek was explored and prospected by some prospectors on their way to the Klondike. They are said to have found hot mineral springs on one of the small tributaries which joins it from the south. They also report the finding of colours of coarse gold on the stream. Sufficient time, however, was not allowed for us to verify either of these reports.

Mount Deception, 1,400 feet in height, stands in the angle between Hungry creek and the Wind river.

Below Hungry creek, the Wind river flows with a slightly accelerated current in the same wide valley. To the east is a level wooded country, probably muskeg, with numerous small lakes on its surface; while to the west is a rolling country which gradually becomes more mountainous farther westward.

As it approaches the Peel river, the valley of the Wind becomes narrower, and the stream is more often confined to one channel. Cut banks appear on either side. These at first consist essentially of clay and gravel, but underlying them farther on are beds of lignite associated with clay and soft sandstone.

Within two miles of the Peel river the valley takes on a cañon-like appearance, bounded on either side by steep walls of sandstone or shales a hundred feet high, and the water rushes between these at a greatly increased speed, so that when it joins the Peel in the cañon, it cuts almost directly across that stream to the opposite wall of rock.

Mountain Section of Wind River

The topography of the mountain section of the Wind river is very similar to that already given for the section at the summit. The vertical relief at the mouth of Nash creek averages about 3,000 feet, but this gradually decreases to 2,000 at the northern border of the mountains.

The general outline of the mountains varies, depending on the character and structure of the rock formations. In the upper part of the Wind river, where the rock formations are principally limestone, the summits are broader and more rounded, and the slopes more gentle and subdued. Near the mouth of the Bear river, where sandstone and quartzites replace the limestone, many high jagged peaks occur, and steep cliffs and precipices border the stream on either side. Extensive slopes of heavy talus and many alluvial fans characterize the region in the vicinity of Bear river. North of this again is a limestone area, which continues to the edge of the mountains, and the character of the topography reverts to the same conditions that hold in the other limestone area.

Though marked cliffs and precipices do occur, the side slopes of the valley can generally be ascended without difficulty. They are wooded only for about two hundred feet above the stream, where steeper slopes of barren rocks and talus begin.

Though the summits of the range show a gradual decrease in elevation from Nash creek, northward, of about a thousand feet, yet at a certain point they break off very abruptly without any foothills, and dip suddenly down to the broad Peel plateau. This scarp-like appearance is only shown from the mouth of the Wind river eastward or on the northern face of the range; but west of the Wind river, where the range swings around in a curve to the north, it loses this feature entirely and instead of breaking off abruptly, is flanked by rounded foothills, which slope gently down to the plateau below.

All data collected with regard to the glaciation of the mountain section of the Wind river point to the conclusion, that the region was not completely covered by a great ice sheet during the glacial period; but that the valleys alone were occupied by glaciers.

The valley of the Wind river was occupied by a large glacier, which filled it to a depth of a thousand feet or more. This had the effect of giving to the valley its present U-shape and of filling the bottom of the valley with a heavy deposit of glacial gravel and clay. Into this deposit the present stream has cut its bed to a depth of fifty feet, leaving only a narrow bench at the base of either slope to mark the level of the old valley.

That the movement of this valley glacier was northward—or down the present grade of the stream—is shown by the drift, which could only have been derived from the rocks to the south.

Existing glaciers were seen only on the flanks of the high mountains directly opposite the mouth of Nash creek. That mountain glaciers have existed along other parts of the Wind River valley, however, is proved by the presence of several basin-shaped cirques, particularly on the western side of the valley. Several hanging valleys also occur, in which the streams occupying them plunge quickly from their own valleys into the valley of the Wind river some hundreds of feet below.

Five miles below Nash creek stratified sands and gravels are exposed in the cut banks on both sides of the stream. These are probably a lake deposit formed by the damming of the stream below. Most of this sedimentary deposit has been eroded away by the later action of the stream, but one or two remnants still stand in the centre of the valley, rising to a height of 150 feet. These are composed of a very fine dark-coloured sand, with less gravel and clay. Other smaller rounded knobs of glacial material occupy the valley below.

The section from Nash creek to the edge of the mountains along the Wind river gives the following succession of rocks from the base upwards:—ferruginous slates and argillites; limestones often weathering red from the oxidation of iron; sandstones with some limestones, which alter to quartzites and crystalline limestones; dark reddish conglomerate.

At the mouth of Nash creek the valley is incised in a series of closely folded black slates, with which occur only remnants of the overlying limestones, lying in steeply inclined synclines. These strike east and west almost directly across the valley of the river and are inclined at high angles, or are vertical. Some of the slates cleave readily along the laminae into broad thin plates, others are more massive. Where they stand vertically they form exceedingly steep slopes flanked at the base by much sharp and broken talus, making it difficult to ascend.

Northward, the limestone, by replacing and overlapping the slates, gradually occupies larger areas, and the underlying slates only appear when brought up by an anticline.

Fifteen miles below Nash creek, at our camp of July 8, a coarse-grained, white sandstone first appears capping the limestone and slates. The limestone is here reduced a few feet in thickness and appears to rest unconformably on the slates. The sandstone lies horizontally, or dips at a low angle to the north. It forms some of the higher peaks in this neighbourhood, and shows the characteristic weathering of this kind of rock in being eroded into all sorts of fantastic shapes. Sharp pinnacles and columns of rock are noticeable features wherever this sandstone occurs. Some of these peaks rise to a height of 4,000 feet above the river.

In places the sandstone is metamorphosed to a white and coarsely crystalline calcareous quartzite, which forms steep cliffs and precipices, particularly opposite the mouth of Bear river. But beyond this again, where the dips are more gentle and the metamorphic action less, the slopes are easier and usually covered with much talus. Alluvial fans are common along the sandstone area.

From Bear river to the edge of the mountains only sandstones and limestones appear in a succession of gentle anticlines and synclines, and overlying these on the edge of the slope is a small remnant of the dark reddish conglomerate.

Fossils are rare in the rocks of the Wind river.

Few indications of economic minerals occur in the rocks of the Wind river, and with the possible exception of iron ore, it is hardly probable that any will ever be found. Quantities of float of a banded, jaspery iron ore were found at the mouth of the Bear river, and I am informed by Mr. C. M. Merritt, of Vancouver, who was up the Bear river in the winter of 1898 and 1899, that the float ore becomes more common higher up the stream, and on the portage to the Bonnet Plume river forms a large proportion of the drift.

The ore is hematite, which weathers to a bright red, and is associated with red jasper. The same float also occurs in great quantities on the Bonnet Plume river and also on the Snake.

Near the northern border of the mountains the variation of the compass is about eight degrees greater than anywhere else, and it is very probable that the local attraction is due to a body of iron ore in the neighbourhood.

Only very fine colours of gold were found in the gravels of this part of the Wind river.

Plateau Section of Wind River

Immediately on emerging from the mountains, the Wind river enters the broad Peel plateau. This is a wide, level, or gently undulating tableland, standing here at an elevation of about 1,700 feet above sea level. Its southern boundary is the range of hills which stretches away eastward in almost a straight line towards the Mackenzie river at the Sans Sault rapid. On the west it impinges against the base of the same range, which swings northward from the Little Wind and continues in that direction to the Arctic ocean. In the great bay, formed by this curve in the mountain range, the level of the plateau is broken by several short ranges of mountains, which are really the foothills of the main range.

These foothill ranges are usually low rounded hills seldom rising more than 2,000 feet above the plateau, and more often less than 1,000. Their origin is due to the same orographic movements in the earth's crust which resulted in the upheaval of the Ogilvie range of mountains. The majority of them are anticlinal in structure; but several are due to faulting on a large scale. Mount Deslaurier, nearly opposite the mouth of Hungry creek, is a good illustration of a mountain formed by a normal fault. This is a west facing fault scarp, which rises abruptly to a height of eight hundred and fifty feet, and then slopes back gently to the east at a very low angle. Before erosion of its summit by glacial action the throw of this fault must have been about 1,200 feet. Several others of the same character occur in the area covered by the foothills.

The foothills area extends northward some distance beyond the Peel river, and its eastern border touches the Snake river. Almost in the centre of this is a large basin, covering over five hundred square miles, occupied by almost undisturbed Tertiary rocks. This basin is almost completely enclosed by the encircling foothills, and lies between the Wind and Bonnet Plume rivers, extending southward from the Peel river some fifty miles. Its surface, which is very little above the bed of the Peel river, is perfectly level and dotted with numerous muskeg lakes. The Peel river skirts along the northern edge of the basin, entering it by a cañon and leaving it by a deep narrow gorge.

East of the Snake river the plateau, which is there 800 feet above the river, continues unbroken towards the Mackenzie river. No hills appear to obstruct the view eastward and the plateau stretches away to the horizon with a perfectly level and unbroken sky-line. It is everywhere covered with moss and wooded with small spruce and tamarack, and holds a few muskeg lakes. To the north it follows the base of the range of mountains, and slopes imperceptibly in this direction to the Mackenzie delta. It gradually narrows in width northward, as the Mackenzie river approaches the mountains, until it is forced to disappear altogether a few miles north of the Rat river where the stream skirts the base of the hills.

Evidences of glaciation on the Peel plateau are rather meagre, and though these show that the plateau was actually covered by a large ice sheet during the glacial period, yet no direct evidence, such as could be deduced from striae, as to the direction of the flow of the ice was obtainable. All the mountains occupying the region between the Wind and Snake rivers have been smoothed and rounded off up to a height of 1,800 feet above the streams. They have the appearance of being in a state of mature dissection, cut by numerous small creeks and having many basin shaped hollows, which are frequently filled with water.

Few of the peaks of the foothills exceed 2,200 feet in height, and those with greater elevation are widely different in their contour from those with a lower altitude. The highest peak of the Illtyd range, which lies east of the mouth of Little Wind river, has an elevation of 2,600 feet above the stream. Its summit is sharp and its highest slopes steep and covered with talus, showing no indication of ever having undergone glacial erosion, and bearing a sharp contrast to the outline of the hills seven or eight hundred feet below.

Rounded pebbles and drift of foreign material were found on the slopes of Illtyd range up to a height of 1,700 feet above the Wind river, and beyond that the surface was covered with broken and angular fragments of the country rock. The range to the east of the Snake river, whose highest points are only about 2,000 feet above the river, has apparently been completely submerged. No sharp peaks appear and water-worn pebbles were found up to a height of 1,600 feet. These consist of limestone, quartzite, granite and some conglomerate, most of which appears to have been derived from the main range to the south.

Some sections, which have been exposed in the valley of the Wind river, show boulder clay and gravel overlying the harder rocks, but as a rule the glacial drift is very thin or is seen only in patches. Eastward to the Snake river it becomes much thicker, but thins again northward to the Mackenzie delta.

The timber on this plateau consists almost entirely of spruce. Birch and tamarack which are totally absent in the mountain section, appear for the first time on the plateau near the mouth of the Little Wind river.

Banksian pine was never seen anywhere, and poplar of two varieties, only on the islands and lower flats of the river.

The height of the timber line on the hills near the Little Wind river is 1,400 feet above the bottom of the valley, or about 3,000 feet above sea level. Relative to the bottom of the valley, the timber line is at about the same elevation down to Fort McPherson; but its absolute elevation gradually decreases northward.

The geology of the foothills section of the plateau region is in marked contrast to that of the mountain section. Three miles from the base of the main range, cliffs 150 feet high, composed of slightly inclined sandstone, appear on the banks of the stream. These cliffs show the following succession from the base upwards:—A fine conglomerate, holding fragments of fossil wood and iron stone nodules, merging into a soft gray sandstone; the latter becomes more feldspathic towards the top, and altering to an arkose. On the top of all is a deposit of boulder clay. This rests on the Palæozoic limestone which forms the country rock of the Illtyd range. The contact between the sandstones and limestones was not seen, but they appear to be conformable, or nearly so. From their lithological resemblance to Cretaceous rocks in other parts of the North-west, the sandstones have been tentatively referred to the same age. No fossils, except the fragments of wood, were found in them.

These sandstones form cliffs on either side of the river down to a point within two miles of the Little Wind river, where they are replaced by the massive gray limestone of the Illtyd range, which here crosses the river diagonally. They have been gently folded into a series of low anticlines and synclines, which strike north parallel to the bordering mountain range, and have no doubt been affected by the orographic movements, which raised them above the floor of the plateau. They almost completely surround the Illtyd range and separate it from the main range to the south.

Illtyd Range

The Illtyd range is anticlinal in structure. It strikes north and slightly west of north, and is parallel to a similar range on the east side of the Bonnet Plume river. It is composed of massive, gray dolomitic limestones, and where it crosses the Wind river, these become slightly crystalline. For two miles the Wind river flows in a gorge-like valley bordered by cliffs of these limestones, and shortly below the mouth of the Little Wind river, it breaks through the range, and enters again the level plateau country. On its northern side the Illtyd range has a very gentle slope, and the limestones dip at a very low angle beneath the overlying Cretaceous sandstones. The highest point of the range is about 4,200 feet above the sea.

Below the Little Wind river, the Wind river widens considerably. It is filled with gravel bars and the valley is shallow. Near Mount Deslaurier it cuts into the eastern bank, exposing a section of soft gray sandstone, 100 feet thick, overlaid by some clay.

Mount Deslaurier itself is a west-facing fault scarp, rising abruptly from the water's edge to a height of 850 feet, and sloping gently away on the opposite side. It strikes parallel to the course of the stream, which it follows for four or five miles. It is composed of about four hundred feet of dark reddish conglomerate, containing angular and water-worn fragments of limestone, quartzite and other rocks; below this is a brecciated limestone, which, near the contact, also carries some foreign fragments. At the water's edge is some sandstone. The latter was probably at first also included in the fault, but later erosive action has worn it all away, leaving now only the conglomerate on the surface.

In the angle between Hungry creek and the Wind river stands Mount Deception, an outlier of the main range to the south. This is a steep anticlinal hill, rising to a height of fourteen hundred feet above the river. It strikes northwest and dips at a very high angle. It is composed of a massive crystalline limestone, which varies in colour from pure white through a mottled, to a dirty gray, with earthy and black streaks.

Below Mount Deception the river enters a low level country underlaid by almost undisturbed Tertiary rocks. The stream occupies a shallow valley bounded by sloping wooded banks so that the contact between the rocks of the Tertiary basin and the older rocks was not seen, except at the mouth of the Wind river.

Coal on Wind River

About twelve miles below Mount Deception, however, cut banks sixty feet in height appear on either side. These at first consist entirely of boulder clay overlaid by gravels, but, farther down, a section of the Tertiary rocks is exposed. This shows six feet of lignite, associated with beds of clay and sandstone, overlaid by glacial drift.

The lignite is still in a primary stage of development, and shows the twigs and leaves of which it is composed, and even some blebs of resin. This seam of lignite is again exposed two miles below, overlaid by six feet of rusty gravels, and resting on a bed of clay. At the base of all is a soft and very fine-grained sandstone, which is also very porous. The lignite when dry burns fairly readily, giving off the odour of burning resin and leaving a great deal of ash. Another section of Tertiary rocks about four miles above the Peel river, and on the right hand side, where the stream cuts directly into the beds, shows the following succession of rocks:

Gravel and boulder clay	40 feet
Unconformity.	
Sandstone with 8 seams of lignite from ½ to four inches thick	50 "
Unconformity.	
Rusty black slates	5 "
Water's edge	95 feet

One mile above the Peel river, the contact between the Tertiary rocks and the underlying slates is well shown in a steep cut bank on the east side of the river. The section shows the great structural break and the lapse of time that must have occurred between the deposition of the two series of rocks.

The following section was measured:

Glacial drift	40 feet
Unconformity.	
Sandstone with beds of reddened shales	30 "
Unconformity.	
Vertical black slates	20 "
River bed	90 feet

The reddened shales in the section probably correspond to the lignite beds of the section higher up, and indicate the previous combustion of the lignite. The slates stand in a vertical attitude, while the Tertiary beds, resting unconformably on the upturned and truncated edges of the slates, dip at a low angle to the east. The tilted surface of the Tertiary beds has been previously bevelled before the deposition of the glacial material, showing a considerable lapse of time between the two periods. The Tertiary rocks are again exposed on the Peel river for a distance of about fourteen miles and will be referred to later.

For the last mile the Wind river flows through a cañon 100 feet deep cut in upturned black slates and shales.

A small creek, which enters the Wind river a mile and a half from the mouth, cuts a deep and narrow gorge through heavy beds of black argillite. The creek has a beautiful waterfall with a sheer drop of fifty feet. The argillites are here seen to dip at a very low angle to the southwest, while at the contact with the Tertiary beds about a mile away they are almost vertical. The texture of these argillites is exceedingly fine-grained, and the largest particles in the rock are crystals of pyrite, which mineral also occurs in vuggs and well defined veins. These rocks are also exposed on the Peel river for several miles above the mouth of the Wind river, and in them the upper cañon of the Peel is cut.

On the bars of the Wind river, two miles above the mouth of the Little Wind river, a great deal of float lignite coal occurs. This is probably derived from the Cretaceous rocks, through which the river flows for some miles above this. The lignite in the Tertiary rocks at the mouth of the Wind river has already been mentioned.

Gold on Wind River

Some coarse colours of gold were panned out from a shovelful of dirt scraped from the rim rock at the mouth of Little Wind river. Coarse gold is also supposed to have been found in the gravels of Hungry creek by the prospectors in 1898, but sufficient time was not taken by us to verify this report. Very little indication, however, of placer gold was found on the bars within five miles of its mouth. As the stream rises in a large lake twelve or fifteen miles up, and flows through a low muskeg country to join the Wind river, it appears to be rather an unpromising place for the occurrence of gold, but some of its tributaries which flow through a more hilly country might carry the precious metal.

By far the largest percentage of the drift of the Wind river consists of limestones and quartzite pebbles derived from the rocks through which the stream flows, and the proportion of quartz is very small indeed. The natural inference one draws from this is that the Wind river does not flow through a markedly mineralized belt of rocks.

Peel River

The Wind river enters the Peel river one mile above the lower end of the upper cañon, or two hundred and one miles above Fort McPherson. A micrometer and compass survey was carried from here down the stream, and through the western channel to where this joins the Mackenzie river, a distance of three hundred and five miles.

Above the mouth of the Wind river the Peel river was not explored for more than six miles, and that by walking along the shore. Few explorers or prospectors have ever been through the upper cañon, which extends from the mouth of the Wind river up to the Aberdeen falls, an estimated distance of about 30 miles. Some of the prospectors in 1898 ascended the stream as far as the falls during the winter, and a year or two later two others descended the stream from its head in rafts, having crossed over the divide from the Twelve-mile river. The cañon appears to be easily navigable for canoes, and no serious obstruction occurs as far as Aberdeen falls, around which a portage is necessary.

The upper cañon is one hundred to a hundred and fifty feet deep, with almost vertical walls of rock. Its average width is about five hundred feet, and the stream flows at a rate of from four to seven miles an hour. When the water is low, it would be comparatively easy to ascend; but, as the water marks show, it is twenty five feet higher in flood, and would then be impassible.

On the 14th of July, with the Peel river at a medium stage of water, and the Wind river slightly higher, comparative estimates were made of the discharges of the two streams. An estimate was made of the Peel river above the mouth of the Wind, by taking cross-sections of the bed and measuring the average velocity for a certain distance. No suitable place for taking the discharge occurs on the Wind river, so the volume and velocity of the united streams was ascertained below the junction. The results show the Peel river to have a discharge almost three times as great as that of the Wind. The actual figures obtained were: 15,136 cubic feet per second for the Peel river alone; and 20,538 cubic feet per second for the united streams. This allows the Wind river a discharge of 5,402 cubic feet per second. These figures are valuable merely as showing the comparative discharges of the two streams, and not for their absolute volume, for the volumes vary enormously at different seasons of the year.

The upper cañon of the Peel river ends one mile below the mouth of the Wind river, and from this point down to the next cañon, a distance of fifteen miles, the river bed has an average width of nearly a mile, most of which, however, is occupied by gravel bars and willow and poplar islands. For this distance the river flows through the low level Tertiary basin before mentioned. The banks of the valley are about a hundred feet deep. On the south side is a level wooded plain, stretching onward to the mountains; while on the north is a great curve in the mountains, the two ends of which touch and cross the river at the upper and lower cañons.

Eight miles below the upper cañon, Mountain creek enters from the north, flowing through the great bay formed by the curve in the mountains.

It is this stream that the Indians follow in making the cut-off across the great bend in the Peel to avoid the lower cañon and swift water; and it was this route that the North-west Mounted Police patrol followed in making their winter journey from Dawson to Fort McPherson. The north end of this trail joins the river at the mouth of Trail creek 120 miles below.

Directly opposite the mouth of Mountain creek are the burning lignite beds noted by Count de Sainville on his map in 1893. It is impossible to say how long these beds have been burning, but for nearly a mile along the bank the lignite has been burnt away, and has so undermined the overlying glacial drift as to cause large landslides. One had only recently occurred in July, and thrown down a great mound of material half way across the stream, so as to divert the water to the other shore. In other parts exposures of reddened clays and shales indicate places from which the lignite has been consumed away.

It seems altogether likely that the burning away of the numerous lignite beds in this section, and the consequent sliding down and washing away of the overlying material, is accountable in some measure for the great width of the valley, which is wider here than in any part of its course below. The main stream follows pretty closely the cut banks on the south side of the valley, where the lignite beds are exposed and burning, and wherever landslides occur the slidden material is very soon dissolved or carried away by the water.

Bonnet Plume River

The Bonnet Plume river joins the Peel from the south, twelve miles below the Wind river. It enters the Peel by a number of channels, forming a delta some three miles wide. As a result of this, it is practically impossible to estimate its discharge, but it is probably larger than the Wind river. It occupies a broad, shallow valley, filled with gravel bars and cut into numerous channels, very similar to that of the lower part of the Wind river. It is said to rise in a large lake in the mountains, and its course is roughly parallel to that of the Wind river. It emerges from the mountains some sixty miles above its junction with the Peel, and flows for that distance through a flat wooded plain, unbroken by any mountains or hills, and underlain probably to some extent at least by Tertiary rocks. As a result its water is very muddy, and it discolours the Peel for some distance below. It was ascended by Count de Sainville for a distance of about twenty miles, but apart from the natives of the country, no other man has ever been far up it.

A sheet of ice occupies a large area at the mouth of Bonnet Plume river and hot springs are said to exist near here. The ice sheet is probably due to the constant flooding and freezing during the winter of the water from these hot springs. A diligent search for the hot springs on the east side of the river led to no discovery, but I afterwards learned that they were situated in the angle on the west side of the stream.

Below the Bonnet Plume river the valley gradually contracts in width, and from a distance appears to close altogether, until the entrance to the lower cañon is reached. Here the stream has cut a deep and narrow defile through the low range of hills which borders the low Tertiary basin on the east side. The banks of the valley quickly rise from a height of a hundred feet to five hundred feet, and from this point down to within thirty miles of Fort McPherson, a distance of 158 miles, the river flows through the high Peel plateau, cutting a deeper and deeper valley northward, until the banks attain a maximum height of 1,000 feet.

This lower cañon is about two miles long. Its average width is 500 feet, bordered by almost vertical walls of thick bedded black slates. At ordinary stages of water it is not at all dangerous to navigation. Except at the entrance to the cañon, where a little rough water and heavy swells occur, the stream though swift is perfectly smooth. The level of floods in the cañon is marked by piles of driftwood, stranded in bays and sheltered spots, and lies thirty feet above the ordinary level of the water.

About half way through the cañon on the right hand bank a lopstick stands to mark the position of two whirlpools, one on either side of the river, which are said to be exceedingly dangerous when the water is high. On the 15th July these whirlpools were only slowly revolving currents and hardly noticeable.

Below the cañon the valley again widens to form a large basin four miles long and a mile and a quarter wide; then gradually contracting again, it turns sharply to the south, and follows a winding course easterly to the Snake river. From the cañon to the Snake river is a distance of about thirty-eight miles, and in this section the stream has a velocity often of eight miles an hour, and seldom less than six. Swinging from one side of the deep valley to the other, it cuts deeply into the soft shales and sandstone rocks, forming steep cut banks, which are constantly dropping fragments of rocks into the rushing stream below. These cut banks alternate with points of gravel and boulders, which are sometimes clothed with a forest growth of spruce, poplar and willows.

The plateau to the south is broken by some low ranges of north and south hills, while to the north it is perfectly level, and carries on its surface several muskeg lakes. It is everywhere forested and covered with moss, which is always frozen a few inches below the surface. A few small patches have been burnt, but on account of the wet or frozen condition of the mossy surface these burnt areas never extend inland far from the river bank.

Between the Bonnet Plume and Snake rivers only a few small creeks enter the Peel, drawing their water from the lakes on the surface of the plateau.

Snake River

The Snake river, which is also called the Good Hope river, enters the Peel in the corner of the large elbow that the latter makes. It was originally supposed to be the larger of the two streams, and because its valley is a continuation in almost a straight line of the Peel valley below, it was taken to be the main stream. An estimate of its discharge, however, proves the Peel to be almost four times as large. The figures obtained for the discharge of the Snake river were 6,960 cubic feet per second, a considerably greater volume than the Wind river, and probably also than the Bonnet Plume. The river is supposed to have been explored by Mr. Bell of the Hudson's Bay Company in 1839, and he speaks of the Snake river as the main stream; but his sketch and description of the lower part of the Peel are so inaccurate, that it is difficult to say how much faith to put in his account of the Snake river. At its junction with the Peel, the Snake river, on July 21, had a width of 350 feet, with a maximum depth of nine feet. The water is a dirty gray colour, flowing at the rate of four miles an hour, and it occupies a valley seven hundred feet deep and about half a mile wide.

The Snake river was explored for a distance of twenty-five miles, and except that there was a slightly accelerated current and many islands, the general character of the stream was unchanged. From one of the neighbouring hills its course through the plateau could be traced for about fifty miles above the Peel, flowing in a northwesterly direction from near the eastern border of the Ogilvie range of mountains. The valley has a cañon-like appearance, bounded by steep banks of fossiliferous soft gray and reddish sandstones, which lie horizontally or are only slightly inclined.

The angle between the Snake river and the upper part of the Peel is occupied by a wide timbered flat. On this spruce trees, tall and straight, with a diameter of 24 inches were common. Birch is also fairly abundant, but few specimens attain a greater diameter than six inches. The other trees are tamarack and balsam poplar with alders and willows.

Peel River (*Continued*)

On mingling its waters with those of the Snake river, the Peel river turns off sharply at a right angle to its former course, and down to Fort McPherson trends a few degrees west of north. From the Snake river to the Fort is a distance of 147 miles, and in this section there is little variation in the general character of the valley. The valley itself has an average width of one mile, the greater part of which is usually taken up with gravel bars or wooded flats, and it is bounded by banks of clay, sandstone or shale, which vary in height from 600 to 1,000 feet. The average velocity of the current gradually decreases, and though it frequently attains a speed of eight it often drops to about two miles per hour.

For thirty-five miles below Snake river it has an absolutely straight course of almost true north, when it bends gradually towards the west, and flows in a general northwesterly direction as far as Satah river, being joined on the way by George creek from the east, and Cariboo and Trail creeks from the west.

George creek is an insignificant stream only about forty feet wide and a few inches deep, having a brownish water probably drawn from muskeg lakes to the east.

For some miles above George river the Peel river flows closely against the eastern side of the valley, forming steep cut banks of clay and sandstone 700 feet in height. These, when composed of clay or shale, form great landslides, or where of firmer rock are constantly dropping blocks and fragments into the stream below.

Directly opposite our camp of July 22, or about three miles above George river, is what Mr. Isbister in his report called the 'Alum Hill'. Some epsomite is here deposited as a thin coating on the clay wherever a little water oozes out from the bank. A little of this white deposit of salt is seen all along the river banks from the Snake river down to George creek; but it occurs in greater quantity at the 'Alum Hill'. Some moose and caribou evidently frequent the place for the sake of licking the salt. The plateau behind the 'Alum Hill', is much broken and dissected by valleys and deep sink holes.

Cariboo creek enters the Peel river from the west twenty miles below George creek. It occupies a valley almost half a mile wide, and out of all proportion to the amount of water flowing in it. It debouches by several channels into the Peel river, none of which, however, are more than six inches deep. The course of the stream could be traced southward for eight or ten miles in almost a straight line.

From Cariboo creek to Trail creek is twenty-two miles by river. The current here becomes noticeably slacker, and there are fewer islands and gravel bars, the stream usually flowing in only one channel instead of three or four as above. The banks of the valley become slightly lower, being about six hundred feet on the east side and eight hundred feet on the west, and at the same time the slopes are more gentle and more frequently wooded. The plateau slopes easily away to the northeast, while it gradually rises to the west. A stream of unknown name, about a hundred feet in width, enters from the east about nine miles above Trail creek.

Trail creek itself is about the same width, (100 feet), flowing in a deep and wide valley from the southwest. It is this stream that the Indians ascend in making their traverse across country to the mouth of the Bonnet Plume river. At this point the swift water in the Peel river begins, in going up stream, and they leave their canoes here and walk across country. Trail creek itself is not navigable.

Satah River

Twenty miles below Trail creek Satah river enters from the east. The stream here has an average velocity of two or three miles an hour, and consequent on this growing slackness, gravel beaches are being replaced by others of sand and clay. Deposits of silt and mud have accumulated in places, and these are occasionally cut into by the stream, exposing sections containing roots, stumps of trees and other material imbedded in frozen muck. Beds of peat too are common.

Four miles above Satah river a small stream enters from the west and directly opposite are the first recent signs of human occupation that we have seen since leaving Beaver river. These are fish stages, and low huts built of bark, logs and clay, looking very much like so many dog kennels.

At Satah river the Peel emerges from the high plateau, and enters what is probably the coastal plains of the Mackenzie river. The transition from the one to the other is very abrupt, and the escarpment of the plateau is about 600 feet high. The northern face of this escarpment, where the Peel river cuts through it, forms a semi-circle which is about ten miles across the base, and the stream after issuing from it skirts along the base of the western arm of the arc. This side of the escarpment has a maximum elevation of one thousand feet above the river, while on the east side this level decreases gradually, until about ten miles away it is only four hundred feet. Enclosed in this arc is a level lake country, underlaid by soft sandstones, and dotted everywhere with lakes of all sizes up to five miles in length. Satah river, which is a sluggish stream about 120 feet wide, drains this lake country, entering the Peel as it emerges from the plateau.

Directly west of Satah river, and at a distance of about twenty-five miles is a range of high snow-covered peaks which McConnell calls the main range of the Rockies. These gradually decrease in height to the south, becoming the low rounded range that crosses the Peel at the upper cañon. The plateau extends up to the base of this range, the evenness of its surface being broken by several low north and south ridges lying parallel with the range of mountains.

Below Satah river the stream makes a wide bend to the west, to avoid which a short cut across country is made in the winter time. From here to Fort McPherson is fifty-three miles, during which distance the stream flows with an even current of about two miles an hour between low banks of clay. Bluffs of sandstone occur here and there. Few islands interrupt the course of the stream, and the average width is about six hundred yards. The stream skirts along the eastern face of the plateau escarpment, sometimes cutting through the projecting points or outliers of it, until as we approach the Fort, it gradually leaves it altogether never to touch it again.

Five streams join the Peel in this section, two from the east and three from the west; the largest of these, which is also the largest tributary below the Snake river, enters from the west twenty-seven miles above the Fort, and is called by the Indians, Road river. This stream, rising in the mountains to the west, is very swift, cutting a deep valley in the high plateau. It has a width at its mouth of about 100 yards.

From Road river down to Fort McPherson several encampments of Loucheux Indians were passed, the first seen since leaving Lansing creek. These spend the summer along this part of the river in fishing and drying the whitefish they catch for their winter's use.

Fort McPherson

Fort McPherson, which stands on the east bank of the river, is the most northern trading post of the Hudson's Bay Company. It consists of the Company's buildings and some houses belonging to the Church of England Mission. These latter are now being occupied by a small detachment of North-west Mounted Police, consisting of half a dozen men under Inspector Howard. There is also another fur trader who has lately started in business.

A careful estimate of the discharge of the Peel river was made at Fort McPherson on the 31st of July, when the level of the water was about a medium stage. Though the water mark of the spring freshet is thirty feet above the level in July, the Peel river keeps at a fairly uniform level all summer, and scarcely falls more than three or four feet below the level when the discharge was taken. The figures obtained for the discharge were 49,206 cubic feet per second. The average velocity is about two miles an hour, and the greatest depth fifteen feet.

Fort McPherson stands on a bank seventy-five feet above the water, and this is the last high land on the river banks. Below this is the flood plain of the great Mackenzie delta, in which all, or nearly all, of the land is submerged in the spring floods. The southern edge of this delta is a line drawn from the Fort to Point Separation, and marked by several low ridges similar to the one on which the Fort stands. From Point Separation the trend of the higher land is northward skirting along the east side of the eastern channel of the Mackenzie, and culminating in a low range of hills called the Reindeer hills beyond Campbell river. West of the Peel river the margin of the delta is the eastern face of the high escarpment mentioned before, which trends slightly west of north from Fort McPherson, crossing the Rat river below the mouth of Long-Stick creek, and gradually approaching the range of mountains west of it, until it merges with this range and disappears at the base of Mount Goodenough. The boundary of the delta north of this is then the base of the mountain range.

Below Fort McPherson the Peel river flows in a straight line northward for twelve miles. It then divides the eastern channel which is a travelled route and has been surveyed by Messrs. McConnell and Ogilvie, joining the Mackenzie river by two mouths another twelve miles beyond.

The western channel, which locally goes by the name of the Huskie river, follows along the western edge of the delta and only joins the Mackenzie waters ninety miles below. There are two large channels of the Peel river between the extreme eastern and western ones, and several smaller ones, all of which would have taken more time than was at our disposal to survey, so that a survey was only carried down the Huskie river and up one of the middle channels.

Huskie River

The Huskie river or western branch of the Peel, has a variable width of from 75 to 200 yards, due to the fact that it is constantly sending off and receiving tributaries from either side. Its current is about one mile per hour, and it is bordered by banks twenty-five feet in height composed of alluvial clays and sands. It is exceedingly crooked, meandering in an exasperating manner over the level floor of the delta. The banks are wooded with willow and alders, with some spruce, which latter gradually decrease in quantity northward until 125 miles below McPherson they disappear altogether.

The south branch of the Rat river, which Ogilvie mapped in 1887, flows into the Huskie river thirteen miles below Fort McPherson, and it was this stream which all the prospectors followed in 1898 on their way across to the Porcupine river.

The central branch of the Rat river joins the Huskie river twenty-one miles below the south branch, and a smaller branch comes in four miles below this. A survey of this central branch was made to connect with Ogilvie's of the south branch, but the northern branch was not explored.

Sixty-three miles below Fort McPherson, the Huskie river approaches within two miles of the base of the Rocky mountains, and here an Indian hunting trail leads into the mountains. An excursion was made to the summit of Mount Goodenough (3,000 feet), from which a good view of the delta was obtained. Under good conditions one is able to see the Arctic ocean from here, but, owing to the hazy condition of the atmosphere, this was impossible at that time. Through the delta several channels of the Peel and Mackenzie can be seen meandering in a very crooked manner; but the most striking feature is the countless number of lakes, large and small, that cover the surface of the delta everywhere. The whole delta is flooded with water in the spring time, and these lakes are probably then filled, while small streams drain them during the rest of the season.

The delta is heavily wooded with spruce as far north as latitude 68° 30′, where it gradually dies out, and only willows and alders remain. These extend northward nearly to the sea, where the recently formed land is utterly devoid of any vegetation whatever. As the new land of recent years is formed and extends seaward, the land formed in earlier years is covered with a group of young willows, while the older land still is marked by a forest growth of larger willows and alders as well as spruce, so that the age of the land can be reckoned by the age and character of the forest growth on it.

Topography of the Peel River District

The topography of the country through which the Peel river flows is simple, and has been occasionally referred to in previous portions of this report. Above the lower cañon and as far up probably as Aberdeen falls, it occupies a wide basin almost completely surrounded by low ranges of hills. Inclosed in this basin are a number of round topped hills or groups of hills, whose origin is due either to faulted blocks or uplifted anticlines. Along the eastern edge of the basin, and occupying a shallow depression in it, is a large area underlaid by Tertiary rocks. These must have been deposited in an inland sea whose boundaries were the encircling hills, and whose outlet was probably by the lower cañon of the Peel river.

Leaving the Tertiary basin the Peel cuts a deep and narrow gorge through the hills bounding the basin on the east, and enters again the plateau region. Through this it flows for 130 miles, cutting a deep valley sometimes a thousand feet deep into the clays, shales and sandstones. Looking over the plateau from any one of the bordering hills, it appears to be perfectly flat, and shows an unbroken sky-line that is uniformly level; but in reality it is made up of several long and gentle undulations, which are perceptible only by careful measurements of the height of the banks of the valley. These undulations have a general north and south trend, lying parallel to the range of mountains against which the plateau abuts to the west. The plateau has a long gentle slope to the northeast towards the valley of the Mackenzie river, while to the north it appears to break off sharply, forming a steep escarpment overlooking the coastal plain. The Peel river breaks through the escarpment at Satah river and enters the coastal plain, though it follows closely the base of the escarpment for several miles below.

Below Fort McPherson is the delta of the Mackenzie river, through which branches of both the Peel and Mackenzie rivers ramify in all directions. The delta covers an area of about 100 miles from north to south, with a width of from twenty-five miles across the south end to sixty or seventy miles across the north. Overlooking the delta from the west side is the northern extremity of the Rocky Mountain system, which extends down to the Arctic coast. Although interrupted in its course northward from the United States boundary line by several deep valleys and streams, and called by different names in different parts of the country, the continuity of this range is practically unbroken, and these mountains west of the delta are really the northern extension of the same range which crosses our southern boundary line. At the delta they rise abruptly to a height of 2,000 feet, and in many parts of the eastern face are inaccessible. Their summits here have the appearance of mature dissection in being well rounded and graded. The highest points are little more than 3,000 feet in height, and this elevation gradually decreases towards the north.

Glaciation in the Peel River District

Reference has already been made to the glaciation in the section of the Peel River watershed enclosed by the foothill ranges. On the plateau to the north and west of this, that is, below the lower cañon of the river, apart from the fact that there has been glaciation to a certain point northward, very little information to supplement McConnell's deductions as to the glaciation on the lower part of the Mackenzie valley was obtained.

Heavy deposits of boulder clay occur in what are probably preglacial depressions near the mouth of Snake river. One section exposed shows 150 feet of dark boulder clay containing boulders of limestone, quartzite, conglomerate and sandstone, all of which were undoubtedly derived from the ranges to the south and southwest. Below Snake river boulder clay lies on the underlying rocks only here and there in patches, and always very thin, scarcely ever exceeding ten feet in thickness. Sections of the Peel valley often show beds of peat occupying the surface, and lying directly on the Cretaceous sandstones without any intervening glacial drift. Other sections show five or six feet of rusty gravel separating the peat from the sandstone.

On the slopes of the high plateau west of Satah river are numerous landslides exposing a dark clay which carries rolled gravel and boulders. This slope is also broken by two benches, one at a level of 50 feet above the river, and the other at 500 feet. On each of these is the same dark clay holding rounded pebbles. On the top of the plateau, which is entirely devoid of timber for some distance inland, a white clay appears lying in round open spaces three or four feet in diameter and fringed with moss or grass. Scattered over these open clay spots are quantities of small pebbles. I have noted the same occurrences on the barren lands, and they have also been mentioned by other explorers in the same region.

In the mountains near the mouth of the Snake river, rolled pebbles were found at a height of 1,600 feet above the level of the stream; but on Mount Goodenough, west of the Mackenzie delta, water-worn pebbles and boulders of gneiss were found on the summit, which is 3,000 feet high. The summit of this mountain is thickly strewn with pebbles, and on its south side at a level of 2,400 feet there is a very heavy deposit, resembling a terrace, of gravel and boulder, both of limestone and gneiss. This rests directly on the broken quartzite flags which constitute the country rock.

Evidence of a small mountain glacier on the east face of Mount Goodenough was seen in a deposit of block boulder clay; no existing glaciers, however, were seen in that region. The slopes and summits of the range are well rounded and have the appearance of mature erosion, though parts of it overlooking the delta break off sharply and present steep and inaccessible cliffs to the eastward.

The few facts observed point to a northerly movement of the ice, for the boulders in the clay of Snake river were evidently drawn from the mountain ranges to the south and southwest. According to McConnell's theory, the ice from the Archæan gathering ground to the east of the Mackenzie river poured westward through the gaps in the mountain on the east side of the river, until it reached the main axial range, and was then deflected to the northeast down the valley of the Mackenzie to the sea. From the mountains to the west only large valley glaciers, from 1,500 to 1,800 feet in depth, issued from the valleys, and spread over the surface of the plateau moving slowly northward and perhaps slightly eastward, until they met and merged with a northwestward moving sheet of ice from the Archæan highlands to the east. The valley glaciers, after leaving the mountains and spreading over the adjoining country, probably covered and rounded off the tops of nearly all the mountains in the foothills belt, leaving only a few nunataks here and there with an elevation sufficient to protrude through the ice sheets.

On account of the softness of the rocks, and the universal covering of moss, glacial striae are never seen on the plateau itself. On the south side of Mount Goodenough, at an elevation of 1,500 feet, grooves and scourings which may be due to glacial action were noticed on a saddle-backed ridge. These have a bearing of N. 20. W., but whether caused by a small mountain glacier, or by the ice sheet which filled the Mackenzie valley, it is difficult to say. The weight of evidence appears to be in favour of the former cause.

Between the base of Mount Goodenough and the Huskie river, and at a distance of about a mile from the river, remnants of an old beach occur. This appears as an abrupt rise of twenty feet above the floor of the delta plain, or forty-five feet above the level of the water, and probably marks a former shore line of the Arctic sea.

Geology of Peel River

The upper cañon of the Peel river is cut in a series of tilted black slates, often dipping up stream. The strata of which it is composed, are alternately thick and thin bedded containing concretionary nodules with crystals and veinlets of pyrite and some bituminous matter disseminated through the rocks. This formation extends for a distance of three-quarters of a mile below the mouth of the Wind river, where it is replaced and overlaid by Tertiary clays and sandstones. The contact is not so well shown on the Peel river as it is on the Wind, though the unconformity between the two is plainly evident. These slates outcrop again fifteen miles below in the lower cañon of the Peel river, so that they border the Tertiary rocks both to the east and to the west. A small outcrop of bituminous limestone, overlaid by the red clay and sandstone of the Tertiary, is exposed one mile below the cañon on the south bank of the river.

When cut through by the Peel river, the Tertiary basin is thirteen miles in width. The rocks of this basin consist of thick beds of soft sandstone, with some thin seams of lignite, overlaid by more sandstone containing pebbles, with clay and some very thick beds of lignite. The whole series has been gently folded into a number of anticlines and synclines. One lignite bed near the top of the series is thirty feet in thickness and fairly persistent, appearing in two exposures four miles apart with a shallow syncline between. This bed rises in an anticline, the top of which has been truncated by later erosion, and beyond, it dips again and disappears beneath the bed of the Bonnet Plume river. Where it appears in the anticline it has been ignited by some cause or other and is now burning. It has been burnt for some distance along the bank of the river, and even across to the east side of the Bonnet Plume river, and has so undermined the overlying glacial drift as to cause extensive landslides. The large seam of lignite contains a fair quality of brown coal, which when dry burns readily, leaving a great deal of ash. The upper layers are separated by thin seams of clay, but the lower part is very pure. The heat of the burning lignite has baked the layers of clay to a bright brick red, which softens and dissolves in the water. Some of it turns a pure white or pinkish colour and is very hard.

Underneath the thirty-foot lignite seam, and separated from it by a thick bed of sandstone, is another seam eight feet in thickness. The whole is covered by about forty feet of gravel and glacial drift.

At the entrance to the lower cañon the Tertiary rocks are replaced by the same series of slates as appear in the upper cañon. This cañon is about two miles long. The slates here stand in a more vertical attitude than in the upper cañon, and strike about northwest. They have been very much crushed and crumpled and many faults appear, while the rock itself has been greatly sheared and brecciated. The lime in the rocks has crystallized out into calcite, and now appears as thin veins ramifying all through the series. The texture of the rock is exceedingly fine-grained, so that its component crystals cannot be distinguished even with a magnifying glass. It contains a large percentage of iron in the form of pyrite, and also some bituminous matter. The series have a banded appearance due to the weathering of some beds white and others black.

Half-way through the cañon a crystalline limestone, which apparently forms the base of the series, has been brought up to the surface in a steep anticline, and forms a narrow band thirty feet in width. The same limestone is again exposed at the lower end of the cañon, where the overlying slates have been thrown upwards at an angle of 45° and eroded away. They appear again north of the limestone, but dipping at a lower angle and showing less the effects of metamorphism. There is probably a fault here, otherwise it would appear as if the limestone overlaid the slates. A short distance below the cañon, the slates are replaced by shales, which dip at a lower and lower angle to the south, until two miles below, they are entirely disturbed and lie horizontally.

Though a diligent search for fossils was made in both cañons, none were found, either in the slates or the limestone, and these rocks are placed in the Devonian merely from their lithological resemblance to rocks on the Mackenzie river which have been referred to that period.

The slates of the lower cañon occupy a belt some two miles wide and were noted on the hills two miles south of the cañon. The same formation is probably continuous through the range of hills, which stretches northward for many miles from the cañon.

From the lower cañon to the Snake river, the river cuts a deep valley 500 to 700 feet in soft shales and sandstone of Cretaceous age. A section of the bank five miles below the cañon shows about 200 feet of yellow and red shales, which towards the base are interbedded with layers of sandstone, resting on massive sandstone fifty feet in thickness. Underneath is about 150 feet of rusty, pyritous shales, very fissile. Overlying all is the glacial drift with a depth of about forty feet. Farther down the stream the banks consist principally of sandstone, with thin beds of shale interposed between sandstone beds. In parts the sandstone contains concretions, many of which are ten feet in diameter.

Apparently the river in this portion cuts through a low anticline, for in the upper part the dips are all up stream and westerly, while near Snake river the dips are in the opposite direction. Towards the centre of this anticline the strata show a good deal of evidence of pressure. A few minor folds occur, and there are several faults. These latter are usually thrust faults, due to contraction and pressure rather than tension.

The Snake river has a deep and narrow valley cut into soft, gray argillaceous sandstones, which lie horizontally or dip at a low angle to the east. The sandstone is massive, but the beds are separated from each other by thin seams of a harder red weathering sandstone wihch contains many fossils of Ammonites.

Two miles above the mouth of the river a small creek enters from the west. This has cut a deep cañon in the soft sandstone, affording a good section. One-third of a mile up the creek are some mineral springs, the water of which gives off a strong odour of sulphuretted hydrogen, while the logs and boulders in the stream are coated with the white substance which is usually found with all sulphurous springs.

South of the mouth of Snake river is a range of hills, whose highest points are about 2,000 feet above the river. This range is built up of hard gray sandstone very similar to the sandstone of the Snake River valley, only a little more indurated and approaching to a quartzite.

The fossils collected in the sandstone of the Snake river have been referred by Dr. Whiteaves to the Cretaceous period (*see* page 205).

Below Snake river the Peel river bends sharply to the north, and down the Satah river, in its course through the plateau, flows parallel with the strike of the gentle undulations in the plateau. In consequence there is little variation in the character of the rocks. Argillaceous sandstones, with interstratified beds of clay in the upper part of the river, merge gradually into sections in which the clay occupies a large portion, or changes to shale. In parts the sandstone contains large concretions. In others it exhibits that peculiar structure due to pressure known as 'cone-in-cone'. Some of these pressure figures have a diameter of fifteen inches, and are either cone-shaped or bottle-shaped. On breaking them open the centre is seen to contain crystals of pyrite and marcasite. The surface of the cone peels off in layers like the layers of an onion, and the different layers are longitudinally striated and slickensided. The structure is supposed to be due to pressure upon concretions in the course of formation.

The clay beds gradually increase in thickness northward, until they predominate over the sandstones, when, they too, become shaly. As already mentioned, these beds at the Snake river are coated with a white crust of epsomite and above the mouth of the George river this coating becomes more pronounced.

Six miles above Cariboo creek is a small exposure of reddened clay shale, which, however, does not appear to be continuous, and immediately below this some lignite float was found on a bar, though the bed from which it was derived was not noticed.

Soft shales, often pyritous, occupy a larger section of the banks below Trail creek, and are associated with a sandstone which carries many fragments of Ammonites. The strata are entirely undisturbed, and the water frequently cuts steep banks which are 600 feet in height. Landslides have frequently broken the banks of the valley into a succession of irregular steps, giving the appearance often assumed in banks formed of the Pierre shales.

On leaving the plateau region at Satah river, the river enters a low lying level country, underlaid by soft sandstones and some conglomerate. Ten miles below Satah river cliffs of this sandstone one hundred feet in height appear on the east bank of the stream, and opposite our camp of July 26, the following section was measured:

	Feet
Soil and peat	20
Rusty consolidated gravels	5
Soft gray sandstone, massive	50
Fossiliferous green sandstone	20
Soft gray sandstone with concretions, also fossiliferous	25
	120

The rusty gravels of this section rest uncomformably on the soft gray sandstone beneath. Three miles below, the gravels disappear, and the peat rests on the sandstone. The green sandstone consists of some layers which are made up entirely of fossils of a variety of *Tellinidae*, and are the same as appear in the sandstone of Rat river below the mouth of Long-Stick river.

Opposite the mouth of Road river a fine-grained conglomerate underlies the sandstone. The conglomerate is made up of a large percentage of sandstone blocks with smaller waterworn pebbles and some lignite fragments in a matrix of white siliceous sand. At the top it passes gradually into sandstone.

A pillar of rock, called by the natives 'Shiltee', eleven miles above Fort

McPherson consists of coarse siliceous sandstone which weathers to a rusty brown and breaks down into a coarse sand. It is twenty feet in height, standing on a hill 300 feet above the river. An interesting Loucheux legend is connected with the history of this pillar. There were originally three pillars, standing as a warning to the Indians as a result of the disobedience of three giants who were turned to stone. Two of these pillars have fallen through the action of atmospheric agencies, and serve to illustrate the rapidity with which such changes take place in a country where there are such extremes of temperature.

As far as Fort McPherson a few isolated hills appear on either side of the bank, exposing the same sandstone as appears at 'Shiltee', but at the Fort this changes to a soft, dark and rusty shale. The sandstone is apparently the same as occurs in the Lower Ramparts of the Mackenzie river, and by the description the conglomerate of the Ramparts is also identical with that of the Peel river.

The bluff on which the Fort stands, like many others in that section, is quite isolated and completely surrounded by the alluvial deposits of the delta formation.

Below Fort McPherson only alluvial sands and clays are exposed in the river banks, which are now scarcely twenty feet in height. Cut banks are very common, and these show the sands and clays overlaid by muck and vegetable matter, all of which is frozen. Cracks and fissures in this have become filled with ice, and wherever the sun's rays beat on them for a while the whole is constantly thawing and breaking down. As the upper layers of this alluvial deposit contain many roots and trunks of trees which serve to bind them together, they do not fall until the underlying beds have been washed away, or until they overhang far enough to be unable to support their own weight. These alluvial deposits are being built up year by year, at the time when the streams are in flood, and inundate the whole delta, and they deposit their load of sediment on the submerged surface. The small streams too, flowing in from the mountains to the west, carry down and deposit annually, a great deal of sediment on the borders of the delta.

Mount Goodenough and McDougal Pass

An excursion was made into the mountains to the west of the delta, and up to the summit of Mount Goodenough. Afterwards in ascending the Rat river, a section of the mountains through McDougal pass was also obtained.

The base of Mount Goodenough lies two miles back from the river. Its eastern face is exceedingly steep, so that a long detour up one of the creeks is necessary to make the ascent from the south side. The mountain range here is made up of horizontal or only slightly folded strata, and characterized by flat or gently rounded tops. Mount Goodenough is 3,000 feet in height; but some elevations to the west of it may slightly exceed this. To the north and northwest there is a gradual decrease in elevation, until the range dips down to the Arctic ocean west of the mouth of the Mackenzie.

The geology of the range is not complicated. At the base is a thick series of black shales, which towards the top contain beds of very hard clay ironstone. These weather red, and the outcrop can be traced by its colour for miles along the eastern face of the mountains. These red beds contain remains of Ammonites, while the underlying and enclosing black shales are also fossiliferous. The shales are gradually replaced upwards by argillaceous sandstones, and these again by siliceous sandstones. These latter become metamorphosed to quartzites and constitute the upper members of the series.

Though the mountains rise abruptly from the floor of the delta, the strata have only a very low dip to the east. Farther to the west they have been more closely folded and frequently faulted. These strata are persistent up the Rat river and across to the Bell river, and have been folded into a series of anticlines and synclines, the whole section being an anticlinorium.

Economic Geology

The rocks of the Peel river below the Wind river are not likely ever to be productive in minerals of economic interest other than coal and lignite.

In panning for gold on a bar on the Peel river above the mouth of the Wind half a dozen fine colours were obtained, showing that this stream contains more of that metal than the Wind river. Gold is reported to have been found by the Indians in the gravels of the Bonnet Plume river, and some specimens were exhibited; time, however, did not permit us to substantiate this report. This stream certainly carries a great deal of magnetic sand in its gravels, and for that reason it goes by the name of the Black Sand river among the Indians. A report is current that a certain prospector picked up a pebble of quartz, which showed some free gold, on a bar in the Peel river about thirty miles below the mouth of the Snake river; but if this is true, the specimen must have been carried there from beyond any part of the river that we were on, and was certainly not derived from any rocks near there.

Iron ore occurs merely as float in the wash of both the Bonnet Plume and Snake rivers. The ore is magnetite and hematite associated with red jasper. The float is widely spread over a great part of the Peel River basin. Mr. Keele found it in large blocks on the Rackla river on the Yukon side of the divide, and it occurs in the wash of Bear river, so that a very extensive deposit of the ore must be situated in the mountain range towards the heads of these streams.

Mineral springs, containing sulphur, occur on a small tributary of the Snake river two miles above the Peel, and small quantities of this mineral are deposited on the boulders in the bed of the stream.

Seams of lignite occupy extensive areas in the rocks of the Tertiary basin at the Bonnet Plume river. The largest seam noted was thirty feet in thickness, another was eight feet, and several varied from two inches to ten. The lignite is not of very good quality, and has been burnt in many places by the fires which have been in existence for many years. Lignite also occurs a few miles above the mouth of Cariboo river, and also in the cañon of the Rat river above the mouth of Barrier river. Many sections of the Peel plateau below Snake river show beds of peat resting on the clay or sandstone, sometimes as much as twelve feet in thickness.

A fissure vein of bituminous coal three feet wide occurs on the right bank of the Peel river ten miles below the lower cañon. It cuts directly across the beds of sandstone and shale, standing vertically and striking 295°. It is very light and soft, burning readily with a red flame, and leaving very little ash. Its origin is probably the bitumen that occurs in the shales and some of the associated sandstones across which it cuts.

The slates and associated limestone occurring in the upper and lower cañons of the Peel river are more or less petroliferous, and afford indications of the presence of oil. Tar oozes out from these rocks in several places, and at the mouth of the Wind river the slates have been reddened, probably by the combustion of the oil which they contain.

Game and Fish

Moose, though found over the whole region explored as far as the delta of the Mackenzie river, are never as abundant as they are on the Yukon side of the divide, and on the Peel river itself are rather scarce.

Caribou are plentiful everywhere in the vicinity of the mountain ranges, some even being found on the plateau.

Bears, both black and grizzly, are plentiful near the summit of the divide, and numbers of them were seen all the way down the Peel river, and particularly on the Mackenzie delta and in the mountains to the west of it.

Numbers of white mountain sheep were seen on both Braine and Nash creeks. In the mountain section of the Wind river several of them were encountered on the banks of the stream, as well as the slopes of the valley. A small band was seen on Mount Goodenough west of the Mackenzie delta, and they are said to be abundant in the mountain range to the west of this; so that the range of this animal covers the whole district explored.

Grayling in the mountain sections, and whitefish, inconnu and pike in the lower parts of the district are the common fish of the country explored.

The Peel River district is inhabited by the Loucheux tribe of Indians, who trade with the Hudson's Bay Company at Fort McPherson. These obtain their living entirely by fishing in the summer, and trapping and hunting caribou in the winter. They make no attempt to build houses, and the cultivation of the ground is impossible, as the surface only thaws out during the summer for a few inches.

Notes on Fossils by Dr. Whiteaves

A. Apparently of Devonian age.

Favosites. Fragment of a massive corallum in which Mr. Lambe thinks he can detect septal squamulae. No. 1, Braine creek.

Productella. Gibbons ventral valves of a small species of productella, with coarse simple or bifurcating radiating ribs.

No. 2. Summit of Braine pass; and Braine pass Nos. 3, 4, 5, 7 and 8.

Atrypa reticularis. Braine pass, number not stated. Impressions or natural moulds of the exterior of portions of two specimens of a brachiopod that may be *A. reticularis*, are labelled Braine pass No. 6.

B. Cretaceous species.

Imperfect specimen of the shell of a strong convex and very inequilateral lamellibranchiate bivalve, rather like *Panopoea* or *Pleuromya* in shape, but with the valves apparently closed, not gaping, behind. Peel river No. 21.

Thracia. Three small and imperfect specimens that seem to be referable to this genus.

Tellina (?). A few tolerably good specimens of a compressed subovate bivalve shell, with very thin test, which may be referable to the *Tellinidae*, or possibly to the *Veneridae*. But none of these specimens show the hinge dentition or muscular impressions.

Inoceramus. The specimen labelled No. 10, though imperfect is large, but the other specimens are mere fragments. Snake river Nos. 9, 10, 11 and 12.

Ammonite No. 1. Large crushed fragments of a smooth species with a narrow venter and umbilicus. Apparently a *Desmoceras* and possibly most nearly related to smooth variety of *D. affine* from the Peace and Loon rivers. Peel river No. 22.

Ammonite No. 2. Cfr. *Desmoceras Liardense*, W., from the Liard river, which was first described by Dr. Whiteaves as *Placenticeras* (*Perezianum*? var.) *Liardense*, in contr. to Canad. Palænt., vol. 1, p. 158, pl. XXI fig. 1, but which has since been doubtfully referred to the genus *Desmoceras*.

A worn fragment of a cast of less than half a volution. Venter and umbilicus both apparently narrow; radiating ribs low, broad and bifurcating or trifurcating. Peel river No. 16.

A small and very badly preserved specimen perhaps of the same species as the preceding, is labelled Peel river No. 17.

Ammonite No. 3. Fragment consisting of a rough cast of the interior of one of the septal chambers. Quite indeterminable even generically, but evidently different from No. 1 and 2. Peel river No. 18.

1906

Introductory Note

In 1906 Dr. A. P. Low was Deputy Minister of the Department of Mines and Director of the Geological Survey of Canada. His Summary Report for that year includes the following notes (page 17) relative to field work in the Yukon:

"Mr. R. G. McConnell, assisted by Mr. Joseph Keele, geologist, and Messrs. F. H. Maclaren and F. O'Farrell, was engaged in measuring the volume, and estimating the values of the high level gravels in the Klondike district. This difficult work has, I am pleased to say, been successfully performed. There has not yet been time to prepare all the available data for the writing of a report on the matter, but as soon as the necessary calculations can be made a pamphlet on the subject will be issued.

"Mr. D. D. Cairnes spent the season in the southern part of the Yukon, where quite a variety of valuable economic mineral deposits have been found and, although quartz mining has just commenced, it is progressing rapidly and in several localities. Considerable work is being done on the Windy Arm silver and gold properties with very good results indeed. Also about 700 claims were located on mineralized quartz veins about fifteen miles west of the W.P. and Y. R'y. between Caribou (Carcross) and Robinson.

"Recent developments on the extensive copper deposits west of Whitehorse have shown them to be richer than expected. Adding to this the fact that there is plenty of available anthracite and bituminous coal in the vicinity, the future looks bright indeed for this district."

KLONDIKE DISTRICT

by R. G. McConnell

The season's work consisted in measuring the volume and estimating as closely as possible the gold contents of the high level gravels bordering Hunker and Bonanza creeks. In this work I was efficiently assisted by Jos. Keele, geologist, and F. H. Maclaren and F. O'Farrell, topographers, all of the Geological Survey staff. I was also fortunate enough to secure the services of such experienced miners as Robert Henderson, the discoverer of the Klondike gold fields, and A. B. McDonald.

In the course of the season all the important bodies of bench gravels along Hunker and Bonanza creeks, and the lower Klondike river, were measured as accurately as conditions permitted. The heavy covering of moss and muck which mantles most of the district rendered the definition of the back line of the gravels in a few places somewhat uncertain, but on most of the hills the outlines of the gravel areas could be closely followed by means of prospecting shafts.

The rocker was employed to obtain the gold values in the gravels. About 350 samples, measuring in most cases a quarter of a yard each, were rocked during the season. The samples where possible were taken in columns six feet in height. Where the gravels were shallow several continuous sections from the bottom to the top of the deposit were washed at intervals along the face. In the deeper deposits continuous columns of the lower gravels only were washed. Above a height of thirty-six feet, samples were taken at intervals of about twenty feet.

In estimating the gold contents of the various gravel deposits due allowance was given to the statements of miners in regard to the values obtained in drifting and hydraulic operations. In most cases the values given agreed very closely with the results of our own work.

No attempt was made to sample the once rich pay streak running through the upper Bonanza Hill gravels. The pay streak in all these hills has been drifted out more or less completely, only occasional pillars and small areas of ground which the miners were unable to reach remaining unworked. These contain the principal values, but their distribution is so irregular that it was considered a closer estimate could be formed by generalizing the results of the various hydraulic operations now in progress than by a limited amount of sampling done by ourselves.

In addition to the Hunker and Bonanza Hill gravels, tests were made of several areas of bench gravels along the Klondike below the mouth of Hunker creek.

Field work was completed at the end of September and Messrs. Maclaren and O'Farrell immediately left for Ottawa, and have been engaged since their arrival in working out the volumes of the various tills. This work, and the estimate of values which depend on it cannot be completed in time to appear in this year's summary report but will be published later on.

Mining on the Klondike creeks is at present in a transition stage. The individual claim-owner is being gradually replaced by companies owning groups of claims and working them with expensive plants. The fabulously rich placers which make Eldorado, Hunker and Bonanza creeks famous have been mostly drifted out and the gravels which remain are too lean, as a rule, to be worked with much profit by the early pick and shovel methods. The necessity for a more economic treatment of the gravels has been met by the introduction of dredges on the creek and river flats, and hydraulic plants on the hills. During the past season four dredges were at work in the district and three others were in course of construction. Dredging in the Klondike where the gravels are thawed presents few difficulties. The gravels are very uniform in size and include few large boulders. The shattered bedrock is also easily excavated by the buckets.

The hydraulic miners have had to depend so far on a small intermittent supply of local gravity water, or on water pumped up from the creeks, and no large plants are consequently in operation.

The insufficiency of the local supply has induced the Yukon Consolidated Company to undertake the construction of a ditch and pipe line designed to bring water from a point on Twelvemile river to the camp. The line has a length of fifty-eight miles and a capacity of over 5,000 miners' inches. When completed it will add greatly to the productiveness of the district.

With twenty-five miles or more of proved dredging ground in the valley flats and tens of millions of cubic yards of low grade but still workable gravels on the benches profitable mining on the Klondike creeks is assured for many years.

Dominion, Sulphur and Quartz creeks on the Indian River slope were not visited during the season. The valleys of all these streams still contain considerable unworked areas of medium grade drifting ground. Quartz creek also is bordered for a couple of miles by an important white channel deposit only partly drifted out.

EXPLORATIONS IN A PORTION OF THE YUKON, SOUTH OF WHITEHORSE

by D. D. Cairnes

I left Ottawa on May 18, with instructions to proceed to the southern part of the Yukon to investigate primarily, the economic resources of certain areas and, incidentally, to gather as much information as possible concerning the general geology and natural resources of the district, and to make such surveys as were required for a map to accompany the work. During the season I was very ably assisted by Mr. H. Matheson.

Windy Arm, Tagish lake, was reached by the usual route and after surveys were completed in the vicinity horses were procured from Whitehorse and work commenced to the north. Just at this time some discoveries of rich gold- and silver-bearing quartz were reported from about fifteen or twenty miles west of Robinson, which is about twenty miles north of Caribou crossing. We examined a great number of the most likely looking claims and continued south to connect with our previous work. Thence work was extended north of the Watson river to within about ten miles of Whitehorse, including the area of the Whitehorse coal field.

By this time, about September 18, the weather became so severe as to prevent further field operations. We therefore tavelled down the river and examined the Tantalus and Five Finger coal mines, as well as the coal on Tantalus butte, and the surrounding country, securing sufficient detail by transit and compass surveys for a sketch map of the district. Afterwards, on my way south from Whitehorse, a couple of days were spent in the Windy Arm district inspecting the latest development in the different mining properties.

General Description of District

The country, generally, consists of wide valleys separated by ridges and groups of mountains, the valleys often containing lakes running, for the most part, in a northwest and southeast direction, approximately parallel to the coast line to the west, but often intersecting in an intricate manner.

In the Windy Arm district the mountains are quite rugged and rise to from 4,000 to 5,000 feet above the valleys. The principal trees are black pine, fir, spruce, aspen and balsam poplar. Some of the valleys, as the lower part of the Wheaton River valley, are very thickly timbered, the tree-line being at an elevation of about 2,000 feet. Farther north, in places, the hills become lower and more rolling and west of Cowley and Robinson rock outcrops are often difficult to find. Extensive muskegs exist in places.

Area Surveyed

The district surveyed this season comprises an area of about fifty miles long and twenty miles wide, extending from the British Columbia boundary on the south in a northwesterly direction to within about ten miles of Whitehorse, the eastern boundary running from Dugdale in a southwesterly direction to the east side of Windy Arm to connect with the northwest corner of Mr. J. C. Gwillim's map of the Atlin mining district, B.C. The western boundary is approximately parallel to this direction and extends from the west side of Lake Bennett on the south to about twenty miles west of Dugdale on the north. In addition to this the sketch map, above referred to, in the vicinity of the Tantalus and Five Finger mines, is being prepared.

General Geology

The geology, particularly in the southern part of the district, corresponds generally with that in the Atlin district, and the geological subdivisions as made by Mr. Gwillim are practically those which have been found best to adopt here.

Extending along the eastern side of the district, sometimes included in this area and at times lying to the east of it, is a rather straight range of limestone hills, probably of Carboniferous age. A few fossils were collected, but have not yet been determined. The limestones overlie a series of older slates, cherts and limestones, which outcrop in a number of places on both sides of Windy Arm and on Nares lake.

Overlying the limestones is a series of altered sediments including some fine-grained generally greenish rocks, which are at times difficult to distinguish from igneous rocks of later age; also some rocks presenting the appearance of much altered slates, although their slaty structure has disappeared. These sediments are in a few localities quite extensively altered to serpentines. The cherts, slates, and altered sediments are included in Mr. McConnell's Tagish series.

Along the western edge of the district are later rocks, the Coast granites, with outlying areas to the east, the granites themselves often becoming quite porphyritic, especially towards the edge of the series. Following along their eastern edge are some older schists, which are partly altered sediments and partly altered porphyries and may correspond respectively to Mr. McConnell's Nasina and Klondike series, in the Klondike gold fields.

Newer than the granites is a somewhat complex series of porphyrites, porphyries, diorites, gabbros, etc., which apparently represent rocks from the same magma, but which differ considerably in character on account of segregation, cooling under different conditions, etc. Towards the edge of this series is a rather complex porphyry, presenting on weathered surfaces the appearance of a conglomerate, due to portions of a harder porphyry being included in a more easily weathered one. The mines of the Windy Arm district are in this series, and for this reason I have called these rocks the Windy Arm series.

Overlying them are some sediments of Cretaceous or Jurassic age, consisting of sandstones, shales and conglomerates, the lower shale beds being considerably altered. A number of fossils were collected, but have not yet been determined. Towards the northern end of the district these sedimentaries are quite extensive and carry valuable coal deposits.

Porphyry dikes cut the sediments and the underlying formations. These later intrusives vary greatly in appearance, but one, carrying very large, long feldspar crystals is very common. Overlying all, particularly towards the north, are basalt and scoria of recent eruption.

Economics

Although numbers of claims had been staked at one time or another, quartz mining, except a certain amount of development on the copper properties just west of Whitehorse, was scarcely attempted until the latter part of the season of 1905, when Col. J. H. Conrad commenced work on the Windy Arm properties, and though so short a time has elapsed a great deal has been accomplished. The little town of Conrad, on the west shore of

Windy Arm, has now several hotels, stores, restaurants, churches and so on, and a mining recorder's office. The whole southern part of the Yukon was formerly included in the Whitehorse mining division, but this summer the district became of sufficient importance to warrant subdivision, and the Windy Arm portion, including most of the Watson and Wheaton Rivers district is now in the Conrad mining district. A number of properties were worked continuously last winter and this summer, and considering the amount of development that has been done, several look very promising indeed.

Many difficulties were encountered. In addition to the fact that the mines are situated high up in the mountain, wood for fuel and timbering was difficult to secure; supplies and wages being high, prospecting work was expensive; and experienced miners were exceedingly scarce. The current wage paid is $3.50 (including board) per day of eight hours.

The district is very accessible. Once the ore is landed on the beach by the aerial tramways now running, it is only a matter of ten or twelve miles around by Windy Arm and Nares lake to the railway at Caribou crossing, and a railway spur can easily be built along the shore for this distance. A good route is also possible from Log Cabin, on the W. P. & Y. R'y., via Whynton, B.C., to Conrad.

Practically all the mining claims in the area surveyed this season were examined and a detailed account of each will be given in the final report: at present, only a few of the most important points in connexion with the more promising properties will be given.

Windy Arm Properties

Some of the most important claims in this district, commencing at the north, are, respectively, the Big Thing group, Montana, Joe Petty, Aurora, Thistle, Uranus, M. and M., Vault, Venus No. 1, Venus No. 2, all owned by the Conrad Consolidated; the Ruby Silver, owned by private parties, and the Venus Extension, Beach, Red Deer and Humper No. 1, owned by the Anglo-American Company.

Big Thing. This property is situated about five miles in a northwesterly direction from Conrad, and differs from all other properties in the district, in that it is in granite formation. In the rest, quartz veins run in true fissures in the porphyrites, etc., of the Windy Arm series. The principal vein on the Big Thing was struck this summer at the end of an eight foot drift. A crosscut was then run sixty feet on the vein, and a winze was sunk which was down about fifty-five feet at the time visited last, early in October. The vein, which dips into the hill and appears to be of the elongated lens type, was widening rapidly in the bottom, becoming almost flat, and was about ten feet wide. The ore is chiefly secondary quartz and is very porous near the surface, showing considerable leaching action. The minerals are mostly oxides and carbonates, which will eventually change to the sulphides, etc. A considerable amount of stibnite, arsenopyrite and pyrite was found near the bottom. Occasional very high assays, running into the hundreds, are obtained in gold and silver, and it is claimed that the ore body will average close to $30 per ton.

The Montana is about four miles south of the Big Thing and, like it and most of the Windy Arm properties, is situated high up on the bleak mountain sides, and all wood, supplies, machinery, etc., have to be packed or pulled up, or carried up on the tramways. A $90,000 double cable aerial tramway runs from the northern extension of the Montana, the Mountain Hero, to Conrad, a distance of 18,697 feet, and has its upper terminal 3,464 feet above the lower.

A drift was run for about 700 feet in on the vein which is from two to five feet in width, with a streak of rich ore eight to eighteen inches next the hanging wall, assaying about $90. The rest of the vein is much leaner and may run $20. The strike is about N. 45° W., with low dips to the southwest. An incline shaft is being sunk on the lead, and about the first of October, when last seen, at a depth of 320 feet, the vein was about eight feet from wall to wall, containing, however, over four feet near the centre, of almost barren, leached, and somewhat decomposed porphyrite intersected by quartz stringers.

The values are chiefly in silver, the chief mineral being galena, though native silver, silver chloride, lead carbonate, argentite, pyrargyrite, tetrahedrite, pyrite and arsenopyrite are also found.

The Joe Petty is situated on the north side of Uranus creek, and contains a strong vein about six feet wide composed of alternating layers of decomposed iron-stained quartz and mineralized country rock. A shaft about fifty feet deep has been sunk on the lead and drifts run each way; at the end of a forty-foot crosscut that cuts the vein in the hill, drifts were also run. No work was done on the property this season.

The M. and M., to the east of the Joe Petty, holds a vein varying in width from twelve to fifteen inches, but it is high grade ore, and can be traced for a considerable distance. The high grade silver minerals, argentite, pyrargyrite, and stephanite were seen here.

The Uranus is situated just across Uranus creek from the Joe Petty. The vein is quartz and is traceable for at least 2,000 feet, with an average width, where seen, of about three and a half feet. The chief minerals are arsenopyrite and galena.

On the *Thistle and Aurora*, higher up the creek, above the Uranus and Joe Petty, surface work was being carried on, for the greater part of the summer, and very rich ore is reported to have been found. The ore is chiefly quartz, carrying chalcopyrite, zinc blende, malachite, and the rich silver mineral stephanite.

The Vault is situated on the side south of Pooley cañon, about 3,000 feet from the beach. When last seen, in October, a drift on the vein was in over 300 feet. This is the same vein, in all probability, as the Venus No. 2, and can be traced for over 4,000 feet. It is in places twenty to twenty-three feet in width, being nearly all well mineralized quartz. In places there are four to six feet of almost solid galena. The vein here, as on the Venus, varies greatly in width, and at times is not more than a foot or so, but on the Vault, so far, except at the surface, at the entrance to the tunnel, the vein is fairly uniform, much more so than on the Venus. An aerial tramway to the beach is under construction, and a shorter one spans the cañon for the transport of wood and supplies. On the whole, this is the most promising looking property in the Windy Arm district.

Venus. A crosscut taps Venus No. 2 about one hundred feet from the entry and drifts were run in the lead about the same distance each way. Some stoping also was done, the vein being eighteen inches to sixteen feet in width. In the stopes there are four to eight feet of good ore which will probably average over $20 in gold and silver. A crosscut intersects the vein at 544 feet where drifts were also run. The vein where opened up in the lower level is narrower and leaner than above, but the narrowing is not likely to be very extensive as the vein looks well both to the north and south.

The chief minerals are galena, lead carbonate, arsenopyrite, chalcopyrite, malachite, pyrite and a good deal of jamesonite and antimony ochre. The ore is chiefly argentiferous galena. Where the vein is wide it consists of alternating bands of quartz and more or less mineralized country rock.

A fifty horsepower gasoline engine operates a compressor here to run the machine drills used on this property, but water-power from Pooley cañon is being installed. An aerial two-bucket tramway 1,525 feet long runs from the lower Venus tunnel to the beach, the upper terminal being 958 feet above the lower.

Some very rich ruby silver ore is found on the Ruby Silver claim to the west of and adjoining the Venus No. 2. The vein is from three to eighteen inches in width.

On the *Venus Extension* are two veins about thirty feet apart. The upper seam has about four feet of good ore, over half of which was being sacked, when visited in October. The sacked ore will probably run $50 to $60 per ton. An incline sunk on the vein was down about forty feet. The lower seam has about two feet of ore, which is chiefly argentiferous galena with considerable arsenical iron and pyrite.

The Beach claim, lying to the south of the Venus Extension, and supposed to be on the same lead as the Humper No. 1, has over ten inches of ore claimed to average about $150 in silver with probably $5 in gold. The chief minerals are galena, argentite, zinc blende and pyrite.

The Red Deer has about six inches of, in places, almost solid galena, which is claimed to run over $90 per ton.

The Humper No. 1 is a particularly promising property, though only about seventy feet of work, which was chiefly in drifts, had been done at the time of my visit. The vein, which can be traced for at least 1,700 to 1,800 feet, is from eighteen inches to four feet in width and carries a large amount of argentite, ruby silver and stephanite, as well as native silver, galena, and pyrite. About eight inches of the vein will average over 300 ounces in silver and a narrow streak of argentite which is quite persistent and has a width of half to three-quarters of an inch, runs 3,000 ounces in silver.

Some native copper is found in the east side of Windy Arm, but the work done is insufficient to determine whether it exists in paying quantities.

The ore values given in this report were obtained from a number of samples taken and also from a great number of assay returns kindly shown the writer by mine managers, mine superintendents, prospectors and others, during the season.

Watson and Wheaton Rivers Properties

Considerable excitement was caused this season by the finding by D. Hodnett and J. Stagar of quartz carrying free gold and telluride minerals between the Watson and Wheaton rivers. The first claim, the 'Gold Reef', was staked, on June 25, on Gold hill, which is situated about fifteen or twenty miles southwest from Robinson siding. Within ninety days of the staking over 700 claims had been located.

A belt, or belts, of schists, approximately half a mile wide, outcrops in a northwest and southeast direction, near the eastern edge of the granites, which often become porphyritic. Dikes of greenish porphyry and porphyrite occur in the granites, also near their eastern edge, and it is in this disturbed belt that the quartz veins were mostly found. They are, as a rule, very persistent and can sometimes be traced for several miles. Outcrops of quartz closely resembling each other are seen in almost straight lines, at short intervals, and with the same general strike from the Watson river to about eight or ten miles south of the Wheaton river, a distance of nearly twenty miles, and although most of the veins found were in this narrow belt, about two miles wide, Mr. Porter and others discovered, towards the close of the season, some deposits of quite pure stibnite, and other minerals, at a considerable distance to the west.

The first discoveries on Gold hill, Hodnett mountain and Mineral hill are all in the line of strike of the veins and just south of the Watson river. The main lead is, for long distances, ten to fourteen feet of almost solid quartz, in places fairly well mineralized with galena, argentite, chalcopyrite, malachite, and pyrite. The vein on the Gold Reef which is in the schists, and is well defined on the surface, appears to be four or five feet in width. A pocket or seam of very rich ore carrying coarse gold was found in this vein from which came also the rich telluride minerals, sylvanite, hessite and telluric ochre. Further work on this claim has disclosed, as yet, no more of the rich minerals.

A group of claims, the Custer, Alice M, and Ramon, staked just south of the Gold Reef on a gray copper lead looked somewhat promising, although no work had been done when seen. The width of the vein was somewhat indefinite on account of wash and slide rock, but is probably about six feet and appears to be well mineralized.

The Legal Tender, staked by Mr. J. Perkins, lies to the northwest of these properties, and is on a very steep rugged hill on the south bank of the Watson river. The vein is in a fissure in the granite, and is three to three and a half feet in width where exposed; it is quartz carrying a considerable amount of argentiferous galena with some chalcopyrite, malachite, and pyrite. The values are chiefly in silver and the vein is claimed to average about $40 per ton.

On Big Bend mountain to the south of the Wheaton river and seven or eight miles southeast of Gold hill, and in the line of strike of the mineral belt, a number of claims were staked by L. Belnew, O. Dickson, J. Perkins and others on strong well-defined quartz veins carrying galena, chalcopyrite, pyrite, etc. Also southwest of this again, in the same direction, on Stevens mountain, and to the west of it, a number of similar looking claims were located by Messrs. Stevens, M. Gilliam and others.

In addition to occasional assays running as high as $300 or over, a number of fairly average assays—from $20 to $60—were obtained in this section, but, with the exception of a small amount of work done on the Gold Reef, no attempt has been made to prove to what extent the veins are mineralized or what values they really carry.

Taking into consideration the large quantity of mineralized quartz in this part of the country and the small amount of prospecting done, the results appear very encouraging and should stimulate both prospectors and capitalists to investigate this belt more closely, particularly to the northwest and west. There are certainly some very rich ores in this section.

Coal, also, was found about two miles to the east of Gold hill, at the same horizon as that in the Whitehorse coal fields to the north, but whether it will be in payable quantities remains to be seen.

A group of four claims known as the Union Mines is situated on the hills just to the west of Annie lake, about nine miles due west of Lansdowne siding and about three or four miles east of Gold hill. These claims were first staked by W. P. Schnobel in 1898, and are supposed to cover the ground known as the 'Lost Mine'. Some development has been done on them and preparations are being made to work through this winter. A ten ton shipment of ore gave, according to Mr. Schnobel, returns of over $20 per ton. The values are chiefly in silver, with a little gold.

Whitehorse Coal

Several seams of anthracitic coal are located in an area known as the 'Whitehorse Coal' and outcrop about twelve or fourteen miles in a southwest direction from Dugdale siding. A tunnel about sixty feet long has been run on one of these seams and a few open cuts have been made; otherwise the coal is entirely undeveloped. The strike at the tunnel is true north 63° west with 42° dip to the northwest. The general strike of the measures, which are quite regular and were traced for over twelve miles, is about north 74° west. The seams measured were nine feet eight inches, ten feet four inches, and two feet six inches, respectively. The samples taken run high in ash, but they were surface samples and with depth the ash will be very considerably less. Probably a number of other seams exist, as the measures have not been prospected to any extent, although they are very favourably situated for so doing, and a small amount of work should give much definite information. There is a very good grade from the W.P. & Y. railway into these claims and, considering their proximity to the Whitehorse copper deposits, the town of Whitehorse, and the Watson and Wheaton Rivers claims, this coal should prove of considerable value in the near future.

Tantulas Mine

This mine is situated on the west side of the Lewes river, about one hundred and ninety miles down the river from Whitehorse, being somewhat less than half way to Dawson. As the coal outcrops here on the river banks it is well situated for economic working. The cars are run out of the tunnels, pulled by cable up an incline, from which the coal is dumped into bunkers, ready for loading. Most of the river steamers burn this coal, of which about 7,000 tons will be loaded this season.

Three workable seams are opened up though only the lower two are being mined at present; others may yet be found as the formation is heavily covered in most places. The coal is worked by the stall and pillar system from two tunnels, which were in about 700 feet when visited in October. Although the seams are dirty, the coal can easily be sorted, but as wages are $5 with board for underground, and $4 with board for surface work, this has not been done as yet.

The following section was measured near the end of tunnels:

Bottom seam —

Coal	2 feet	4 inches.
Shale	0 "	7 "
Coal	2 "	0 "

Shale	0 feet	6 inches.
Coal	2 "	11 "
Shale	4 "	0 "
Middle seam —		
Coal	2 "	3 "
Shale	0 "	2 "
Coal	0 "	7 "
Shale	0 "	2 "
Coal	2 "	0 "
Shale	0 "	2 "
Coal	1 "	8 "
Shale	7 "	0 "
Top seam —		
Coal	3 "	0 "
Shale		

These measures are quite regular, and can be traced for over twenty miles down the Nordenskiöld river to the south and over ten miles to the north, showing that there is an enormous amount of coal in this district; when the measures have been prospected they may be found to extend much farther. Only coal near the river is, at present, of economic value. The dips are to the east and vary from 24° to 40°. Samples taken show the coal to be a bituminous coal that yields an average of about 75 per cent of a firm coherent coke.

At Tantalus butte, across the river from the Tantalus mine, the same measures again outcrop, but dipping to the west, showing the presence of a synclinal fold in between. The coal outcrops are near the top of the butte about four hundred feet above the river, having wash and terrace material covering the formation lower down. The best seam seen had five feet of good, firm, clean looking coal with one foot more of coal and shale on the bottom. Other seams seen were dirty and narrow, but there may be good ones obscured by the drift, etc., as practically no work has been done, except small surface cuttings. Altogether, the general conditions of the measures are quite similar to those at the Tantalus mine and this property will probably be worked in the near future. The surface samples obtained did not give a firm coke, but this coal is likely to coke with depth.

Five Fingers Mine

This is situated on the east side of the river about eight miles north of the Tantalus mine. A considerable amount of coal has been shipped from here, but the old workings, being dangerously situated on the steep clay and sand banks of the river, are not now used. The slope, at present being sunk, is to the north and in safe ground, and at the time visited was down about 525 feet, dipping to the east at 16°. The seam at this depth was about two feet wide, and was apparently becoming wider. It had once narrowed to about six inches. An average of two feet yielded 55·5 per cent of firm coherent coke. These measures are not the same as those at the Tantalus mine, but are below them. The upper measures outcrop in the valley to the east of the ridge of hills just above the mine.

Conclusion

Considering that quartz mining has so lately commenced in the southern part of the Yukon, the results are exceedingly encouraging. Just to the north of the Windy Arm and Watson and Wheaton Rivers properties are the rich and extensive copper deposits west of Whitehorse. The Pueblo, in particular, after this season's development, presents an enormous surface showing of copper ores. A Whitehorse smelter is a probability in the very near future, especially as there is plenty of available coal in the metallurgical coke. Plenty of water power is also obtainable from Miles cañon.

In conclusion I wish particularly to thank Col. J. H. Conrad, Robt. Lowe, Wm. Granger, Theo. M. Daulton, and others for assistance during my season's work and for courtesy shown to myself and party.

REPORT ON GOLD VALUES IN THE KLONDIKE HIGH LEVEL GRAVELS

by R. G. McConnell

A general report by the writer on the geology, topography and gold-bearing gravels of the Klondike district was published by the Geological Survey in 1905. The present report, although a few other subjects are briefly discussed, is special in its object and deals principally with the values still remaining in the bench and creek gravels and especially in the important high level deposit known as the White Channel gravels.

Classification of Gravels

Low level gravels..................	Gulch gravels. Creek gravels. River gravels.
Gravels at intermediate levels.......	Terrace gravels.
High level bench gravels............	Klondike gravels. White Channel gravels.

The gravels enumerated in this table are fully described in the report referred to above and only certain points on which additional information was obtained need be treated at length. The diagram on page twenty-one shows the relationship of the various types on the lower part of Bonanza creek.

The White Channel bench or hill gravels are the oldest in the district, and, excepting the present creek gravels, the most important from an economic standpoint. They were originally creek gravels, deposited in a similar manner to those occupying the low levels at present, and their elevated position is due to an uplift which affected the whole region bordering the Yukon from the Stewart river northwest to the Alaskan boundary and for a considerable distance beyond. This uplift, and a small depression which preceded it, produced many notable changes in the topography of the country.

It is probable, although not conclusively proved, that during the White Channel period the lower portion of the Klondike valley, the portion into which the principal gold-bearing creeks discharge, was occupied by a small local stream and that the Klondike itself flowed either into the Stewart or into Twelve-mile river. The White Channel deposits are remarkable in this respect that even when completely destroyed their former position is marked by a trail of gold. They are traceable in this manner from the present mouth of Hunker, Bear and Bonanza creeks far out into the present valley of the Klondike, showing that the old valley was small, smaller than that of Hunker creek and unlikely to have contained a large rapid river such as the Klondike.

At the close of the White Channel period the district was depressed, and it was during this depression that the Klondike is considered to have broken into its present valley. It brought down an immense quantity of material from its upper reaches, and rapidly built up a wide gravel bed fully 150 feet in depth. These gravels at the mouth of Hunker and Bonanza creeks rest on the White Channel deposits and at other points, where not destroyed, are distributed along the hill sides at the same level. They are composed principally of well-rounded pebbles of quartzite, hard slate, diorite and occasionally granite, all, unlike the other gravels, foreign to the district, and so far not proved to be of much economic importance.

The depression was followed by an uplift of approximately 700 feet, which gave new life to all the streams by increasing their grades, and they immediately commenced to deepen their channels. This process was continued not only through the old gravel deposits but down into the bedrock to a depth of from 150 to 300 feet. The new valleys are sunk, as a rule, through the bottom of the old ones, but in a few places, as at the mouth of Bonanza creek, they deviate from them and have carved out independent courses.

The difference in character between the old and new valleys is striking. The old ones represent the product of long continued stable conditions, and are characterized by wide flats and gently sloping sides, from which all traces of angularity have been smoothed away. The flats of the old Hunker creek valley have a width in places of over a mile. The new valleys on the other hand, while opening out into occasional basins, are generally narrow, steep-sided and angular. This applies only to the creeks, all of which are small, as the Klondike river has cut a huge trench through the district since the uplift.

Only a portion of the deposits of the old valleys was destroyed during the excavation of the recent valleys, as the latter are much narrower and do not follow exactly the same courses. The undestroyed portions constitute the White Channel gravels of the miners.

White Channel Gravels

The White Channel gravels differ somewhat from the ordinary type of stream deposit. They are very compact as a rule and in some of the hydraulic cuts stand up in almost vertical cliffs, even when the face is unfrozen. The white or light gray coloration from which the deposit derives its name is very conspicuous in most of the sections but is not universal, as red, yellow and dark gray beds frequently occur. The deposit is highly siliceous, the principal constituent consisting of rounded pebbles and rounded and subangular boulders of vein quartz. Flat schist pebbles and boulders, usually in a more or less advanced stage of decomposition, occur with the quartz, and also occasional pebbles derived from the various dikes and stocks outcropping along the valleys. No material foreign to the district occurs in the deposit. The pebbles and boulders are usually small, seldom exceeding eighteen inches in diameter, and are embedded in a compact matrix consisting essentially of small sericite plates and fine angular quartz grains. A few large angular blocks from three to four feet in diameter are occasionally met with but are rare and usually occur on or near bedrock.

The uniformity of the deposit in composition and general character throughout sections a hundred feet or more in thickness is very striking. The bedding planes, as a rule, are inconspicuous, and there has been no sorting of the various constituents into separate beds.

The deposits, unlike the creek and gulch gravels, appear to be destitute of vegetable and animal remains. None were found by the writer and the few reported discoveries by miners lack confirmation.

The thickness of the White Channel gravels varies from a few feet to 150 feet and the original width from a couple of hundred yards to over a mile. The volume of the deposit on both Hunker and Bonanza creeks increases steadily down stream.

On Gold, Adams and other hills on Bonanza creek the typical compact white variety of the White Channel deposit is replaced towards the sides of the old valley by flat rusty coloured gravels, more loosely bedded and containing a smaller proportion of quartz than the ordinary white variety. These probably represent flood plains deposits. They have the appearance of overlying the white variety and were formerly, in the absence of sections, considered to be younger. The long exposures, however, now available for study in the various hydraulic cuts, show that the two varieties pass gradually one into the other both horizontally and vertically and in places are interbanded, evidence of contemporaneous deposition. The loose yellow variety is seldom productive.

The White Channel gravels were probably deposited by winding streams with easy grades and comparatively slack currents. The preponderance of vein quartz pebbles and boulders, the most resistant rock in the district, gives them the character of a residual deposit. They were built up slowly and in the long process the softer rocks were mostly destroyed and carried away.

The great length of the White Channel period is indicated by the enormous gold accumulations, all derived from the slow breaking up of auriferous quartz veins which took place in it. Since the close of the period the additions to the supply have been trifling, although a sufficient time has elapsed to enable small streams to excavate channels, mostly through hard schists from 300 to 600 feet in depth. Practically all the gold in the present low level valley flats is of secondary origin and derived from the partial distribution of the older gravels.

The age of the White Channel gravels has not been determined, but they must date back to the Pleiocene at least. They were certainly deposited before the advent of the present severe climatic conditions, as the white coloration is largely due to the leaching out of the greater portion of the iron by circulating surface waters, and this must have taken place before they were permanently frozen.

Distribution of Gold in Gravels and Bedrock

The greater part of the gold both in the hill and creek gravels occurs on or near bedrock, either in the lower four to six feet of gravel or sunk for some distance in the bedrock itself. The distribution depends largely on the character of the bedrock. Soft schists such as those underlying the rich portion of Upper Dominion creek prevent the gold from descending, and it accumulates in a thin layer at the base of the gravels. In many of the rich claims between the two discoveries on Dominion creek a thin stratum of gravel resting immediately on bedrock proved extraordinarily rich, while the bedrock and the upper gravels were comparatively lean. On Bonanza creek the bedrock as a rule is harder and more flaggy, and the action of frost has parted the layers and allowed a portion of the gold to descend along them. From three to five feet of bedrock are usually mined at a profit, and gold has been found in some quantity at a depth of twelve feet and probably descends still deeper.

On a couple of claims on Hunker creek below the mouth of Seventy pup practically all the gold occurred in a shattered porphyry bedrock, the overlying gravels proving almost barren.

The bedrock underlying the White Channel gravels is more decomposed than that in the creek bottoms, does not open out in the same way and retains most of the gold at or near the surface. In a few places gold has been found in paying quantities in the schist partings under the decomposed layer, but as a rule only the upper few inches are mined.

The rapid decrease in gold values in the White Channel gravels above bedrock is shown in the following table which gives the average values obtained in sampling Trail and Lovett hills. The samples were taken in successive six foot columns.

			Total value
144–150 feet.	Average value per cubic yard	.006....	.012
138–144 "	" "	.007....	.014
132–138 "	" "	.008....	.016
126–132 "	" "	.009....	.018
120–126 "	" "	.009....	.018
114–120 "	" "	.010....	.020
108–114 "	" "	.010....	.020
102–108 "	" "	.011....	.022
96–102 "	" "	.011....	.022
90–96 "	" "	.012....	.024
84–90 "	" "	.013....	.026
78–84 "	" "	.015....	.030
72–78 "	" "	.020....	.040
66–72 "	" "	.020....	.040
60–66 "	" "	.021....	.042
54–60 "	" "	.023....	.046
48–54 "	" "	.025....	.046
42–48 "	" "	.045....	.090
36–42 "	" "	.030....	.060
30–36 "	" "	.032....	.064
24–30 "	" "	.034....	.068
18–24 "	" "	.040....	.080
12–18 "	" "	.047....	.094
6–12 "	" "	.180....	.360
1–6 "	" "	$4.130....	8.260
Total values in square yard column fifty yds. high.			$9.532

The values in the lower four yards, including a foot of bedrock, average $2.15 per cubic yard, while those in the upper forty-six yards of the column average less than two cents per cubic yard. The decrease in values from the bottom to the top of the section proved to be constant, except at one point forty-five feet above bedrock where a slight enrichment takes place.

The following table shows the values obtained in a square yard column of the White Channel gravels in the Last Chance creek slope of Dago hill:

			Total value
84–90 feet.	Average value per cubic yard	.007....	.014
78–84 "	" "	.009....	.018
72–78 "	" "	.012....	.024
66–72 "	" "	.014....	.028
60–66 "	" "	.020....	.040
54–60 "	" "	.0675...	.135
48–54 "	" "	.0275...	.055
42–48 "	" "	.030....	.060
36–42 "	" "	.041....	.082
30–36 "	" "	.040....	.080
24–30 "	" "	.0425...	.085
18–24 "	" "	.050....	.100
12–18 "	" "	.060....	.120
6–12 "	" "	.114....	.228
1–6 "	" "	$2.200....	$4.400
Total values in square yard column thirty yds. high.			$5.469

In this column a considerable enrichment takes place at a point sixty feet above bedrock. The enriched gravels have a thickness of a few inches only and rest on a compact clayey stratum not easily penetrable which acts as a bedrock. The gold is moderately coarse, much coarser than that in the gravels immediately above and below, but finer than that on bedrock.

A marked exception to the general rule in the district, that the gold decreases in quantity and coarseness from bedrock upwards, occurs on Paradise hill on Hunker creek. The main gold zone here in many places is found not in bedrock but at elevations of from three to twelve feet or more above it. A section of the gravels twenty-four feet thick a short distance below Hester creek gave the following values:

18–24 feet.	Average per cubic yard	$ 0.025........	$0.050
12–18 "	" "	0.266:......	.532
6–12 "	" "	0.776........	1.552
1–6 "	" "	0.576........	1.152
Total values in square yard column eight yds. high...			$3.286
Average values per cubic yard.....................			42.1 cents.

The lower gravels in this section and in other places on the hill are very siliceous, consisting almost entirely of vein quartz pebbles and boulders. The siliceous layer varies in thickness from a few inches up to eight or ten feet, and is overlaid by gravels containing a greater proportion of schist pebbles. The best drifting ground worked so far occurs above the siliceous layer, in the lower part of the upper gravels.

The gravels on Paradise hill although rich in places have seldom paid to drift on account of this irregular distribution of the gold. The pay zone, in place of lying in a plane, undulates along the surface of the uneven siliceous gravels and is very difficult to follow.

The concentration of all the coarse, and the greater part of the fine, gold in the White Channel gravels on or near bedrock seems incapable of explanation except on the assumption that the gravels have been worked over probably several times by the stream that deposited them. The deposit is over 150 feet thick in places, is very compact and includes numerous medium sized and a few large angular boulders which would serve to intercept a portion of the gold if it descended under the influence of gravity alone. That they have not done so is shown by the fact that in all our sampling not a single coarse piece was found in the upper gravels.

Grade of Klondike Gold

Klondike gold varies greatly in grade not only on different creeks but also along different portions of the same creek. The difference of grade is due to the gold being in all cases alloyed with silver in varying proportions. The lowest grade gold in the camp occurs on Big Shookum and Henry gulches and has a value of about $12.50 per ounce. The highest grade gold on the Klondike creeks is found on Upper Hunker creek where assays occasionally exceed $17.50 per ounce. The gold from Gold Run creek on the Indian river slope averages over $17.50 per ounce and assays of $17.75 per ounce are reported from Allgold creek.

The average value of all the gold shipped from the camp in 1905 according to the U. S. Mint returns amounted to $16.02 in gold and 10.94 cents in silver per ounce.

In the lowest grade gold the silver almost equals the gold in volume, the ratio being 1 to 1·4. In the high grade gold the ratio is 1 to 5 and the general average is 1 to 2·3. In value the ratio of silver to gold is very small, the proportion calculated from a number of returns being approximately 1 to 150. The total gold production of the camp is estimated at $119,000,000 and the silver at $793,000.

The variations in grade along the different creeks, as shown by assays furnished by the Bank of Commerce, are interesting. Bonanza Creek gold above Eldorado forks is fairly uniform in grade, running from $16.73 to $17.09 per ounce. The average grade decreases slightly but not uniformly down stream. Below the Eldorado forks the influence of the inferior Eldorado gold is shown by a sudden decrease in value to about $16.00 per ounce. Farther down in the rich section above Discovery claim the grade drops to $15.75 per ounce. Below Discovery claim the value increases to about $16.15 per ounce and remains at that figure down into the Eighties, a distance of eight miles. Towards the mouth of the creek the grade again increases to over $16.50 per ounce.

Eldorado creek gold has an average value of $15.70 per ounce, about a dollar less than that from Bonanza creek above the forks. The difference in grade is somewhat remarkable as the two streams cut the same rocks, are never far apart, and must have drawn at least a portion of their supplies from a common source, viz.: the comparatively narrow ridge separating them. Gulches cutting back into this ridge from both creeks have proved productive. Eldorado gold is generally coarser than that from Bonanza creek, and its inferior grade may be due to this cause, as fine gold everywhere throughout the camp assays higher than the accompanying coarse gold.

The grade of Hunker creek gold is extremely variable, ranging from over $17.50 per ounce in the upper part of the creek down to $14.50 below Henry gulch. The grade decreases slowly down stream from Discovery claim to Hester creek, then drops suddenly over a dollar an ounce. Paradise hill gold below Hester creek averages about $15.20 per ounce. Farther down on Dago hill the grade increases again to $16.50 per ounce, then drops down to $14.50 per ounce near the mouth of the creek. Last Chance creek, a tributary of Hunker creek, and Bear creek, a parallel stream emptying into the Klondike, both contain low grade gold, assays seldom exceeding $15 per ounce.

The Indian river creeks average higher in grade than Klondike river creeks. Dominion creek gold above Gold Run averages about $16.90 per ounce. Below Gold Run the grades increase to $17.50 per ounce. Gold Run gold maintains an average grade along the main pay streak of fully $17.50 per ounce. Sulphur creek gold is somewhat lower, averaging about $16.50 per ounce.

The variation in grade of the placer gold appears to depend mostly on original differences in grade of the vein gold from which it was derived. Creeks draining certain areas in the district carry low grade gold, while other areas supply high grade. An important centre of dispersion for low grade gold occurs west of the lower portion of Hunker creek. Hester and Last Chance creeks, Henry gulch and Bear creek all head in the same ridge within a comparatively short distance of each other and all carry low grade gold. Big Shookum creek, a tributary of Bonanza creek, heads in a low grade area and the gold brought down by it lowers appreciably the general grade of the Bonanza creek gold for several claims. The Dome and surrounding region furnishes a good example of high grade area. The streams flowing outwards from this centre, including Upper Dominion, Upper Hunker, Sulphur and Gold Bottom creeks, all carry high grade gold although the values differ considerably.

While the grade of the placer gold is supposed to conform in a general way with that of the original vein gold some changes are evidently produced by the leaching out of a portion of the silver contents.

M. Carey Lea in a series of articles in the American Journal of Science, commencing in Vol. XXXVII, p. 491, has shown that silver passes readily when treated with certain re-agents into an allotropic form, one of the distinguishing characters of which is its easy solubility, and the same process may go on in nature.

Evidence of loss of silver is afforded by the fact that fine gold which would necessarily be affected more by leaching than the accompanying coarse gold invariably carries a smaller percentage of silver.

Nuggets also assay higher as a rule on the surface than in the centre. Five assays of selected nuggets made by Mr. Connor in the laboratory of the Survey gave the following results:

	Centre of nugget	Surface	
1 Silver.......	35·8	29·4	Trail hill, Bonanza creek.
Gold........	64·2	70·6	
2 Silver.......	39·9	33·5	Chechaco hill, Bonanza creek.
Gold........	60·1	66·5	
3 Silver.......	37·3	30·3	Bonanza creek, No. 12 below.
Gold........	62·7	69·7	
4 Silver.......	46·1	41·0	Treasure hill, Last Chance creek.
Gold........	53·9	59·0	
5 Silver.......	33·0	33·5	Bonanza creek, No. 3 below.
Gold........	67·0	66·5	

All the nuggets with the exception of No. 5 show losses in silver of from five to seven per cent on the surface, assuming that the composition was originally uniform. No. 5 was a large nugget filled with quartz and its exceptional character is probably due to its being much younger than the others.

Transportation of Gold

The two main factors in the transportation of coarse gold by natural causes are grade and bedrock. With steep grades and smooth bedrock transportation is comparatively rapid, while little movement takes place when the grades are moderate and the valleys are floored with the tilted flaggy schists characteristic of the district.

The Klondike slopes are everywhere mantled with a thick covering of broken and partially decomposed schist fragments easily moved when not frozen and ever tending downwards towards the creek and gulch levels. The downward movement is slow and intermittent at present on account of the perpetually frozen condition of the surface, except on sunny slopes. During the period of the White Channel gravels, the period of the great gold accumulations, climatic conditions were less severe and the movement must have been much more rapid.

The slide material carries with it the gold and gold-bearing quartz released by the breaking up of the auriferous quartz veins, and when running water is reached the gold is sluiced out and remains behind, while the rock fragments are ground up and carried away.

The distance travelled by the gold after reaching the waterways, neglecting the time element, depends on the grades and bedrock. The upper portions of the creeks, and the steep gulches, except where they cross the paystreak of the White Channel gravels and are directly enriched from them, have not proved rich and are only occasionally productive. The gold washed down into them moves slowly on, and all the great accumulations occur on portions of the creeks with grades of 150 feet or less to the mile. The rate of movement diminishes rapidly with the grade and near the mouths of the creeks is excessively slow.

Evidence of the tardy movement of coarse gold down streams of moderate grade, even where the latter are actively engaged in eroding their channels, is furnished at many points along Bonanza and Hunker creeks. The paystreak of the elevated White Channel gravels has been destroyed in places along both these streams. Whenever this occurs the creek bottoms directly opposite the destroyed portions are immediately enriched, showing that the gold, or a large portion of it at least, has remained almost stationary during all the time the creeks were employed in deepening their channels from 150 to 300 feet. The horizontal movement in some instances scarcely exceeds the vertical movement. The complementary relationship existing between the creek and the hill pay gravels has been recognised by the miners, and whenever the creek gravels are lean, pay is confidently expected on the hills, and in the productive portions of the creeks is usually found.

The influence of bedrock in retarding or accelerating the progress of gold down stream is almost as important as that of grade. The common bedrock of the district is a light coloured flaggy sericite schist of unequal hardness and usually tilted at high angles. The sericite schist alternates in places with bands of dark graphitic schists and is broken through by numerous porphyritic dikes and stocks. The light coloured flaggy schists when hard form an excellent bedrock from the miner's point of view as they weather unequally into irregular rock ripples which arrest the progress of the gold. The partings also open out under the influence of the alternate freezings and thawings to which the rocks are subjected and the gold descends along them, and continues to descend as the surface is gradually lowered by erosion. Its progress down stream when caught in this manner is indefinitely delayed.

The porphyritic rocks when shattered, as is often the case, also arrest most of the gold. The soft varieties of the sericite schists and the dark graphic schists, on the other hand, offer small resistance to the passage of the gold. They weather to a smooth surface along which the gold moves easily, and the portions of the creeks underlaid by them are usually lean.

Valuation of High Level Gravels

All the high level gravels along Hunker and Bonanza creeks, and the Klondike river below Hunker creek, considered to be of economic importance, were measured as accurately as conditions permitted. Two six inch stadia transits were used for this purpose and proved very satisfactory. The outlines of most of the areas could be defined very closely as nearly all the hills have been thoroughly prospected by drifts and shafts. In a few places where the surface is muck-covered the back limit of the gravels could only be drawn approximately, but the total error from this source is not believed to be large. The aggregate volume of gravels measured amounted to 345,000,000 cubic yards.

Sampling was carried on continuously throughout the season and all the important hill areas, except the Upper Bonanza hills, were examined as carefully as the time at our disposal allowed.

The sampling was done with rockers built specially for the purpose. The usual sample consisted of a column of gravel a foot square, each successive six foot section being washed separately. When the gravels were shallow continuous sections from the bottom to the top of the deposit were washed. In the deeper deposits continuous columns of the lower gravels only were washed. Above a height of thirty-six feet samples were taken at intervals of about twenty feet.

On most of the important hills long faces opened out by hydraulic operations, and numerous drifts and shafts were available for examination. Where these were absent shallow cuts and shafts were sunk at intervals by ourselves.

In estimating the gold contents of the various gravel areas due allowance was paid to the statements of miners in regard to the values obtained in drifting and hydraulic operations. In most cases the values given agreed very closely with the result of our own work.

The estimate of values in the Upper Bonanza hills and in the low level creek gravels is based almost entirely on the results of actual mining work and on information (carefully examined and sifted) obtained from miners and others familiar with the ground. The gravels have all been more or less mined and the remaining values are distributed so irregularly that effective sampling in the time at our disposal was obviously impossible.

The values in the smaller hills, many of which are held separately, are grouped together in order to avoid affecting individual interests. The larger hills as a rule are divided up among a number of different owners.

Bonanza Creek High Level Gravels

The White Channel gravels once continuous along Bonanza creek and its main tributaries have been partially destroyed by the deepening of the valleys, and have been cut through transversely at various points by tributary creeks and gulches. They are now represented by a number of separated areas distributed at irregular intervals along the valleys and designated by the miners by different names. With the exception of French hill on Eldorado creek none of the areas on the tributary streams have proved of much importance.

The White Channel gravels on Bonanza creek above the Eldorado forks, and on Eldorado creek, have been mostly destroyed and the gold contents washed down into the present low level valleys. The extraordinary richness of these valleys is due to this fact. The principal areas which have been preserved are Bunker hill, below Gauvin gulch on Bonanza creek, and French hill below French creek on Eldorado creek. Besides these, small patches, now mostly worked out, have been preserved on Bonanza creek below McKay and Homestake creeks and on Eldorado creek above Oro Grande gulch.

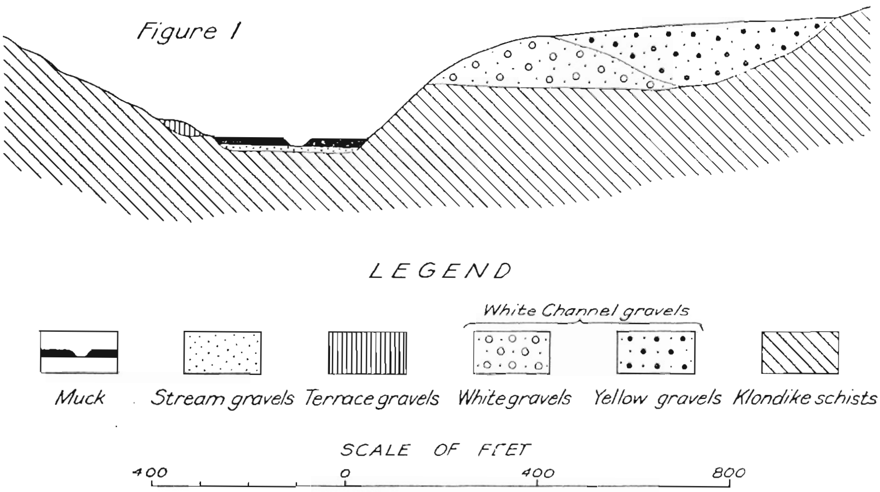
The most important strip of hill gravels on Bonanza creek at present commences at the Eldorado forks and extends down stream on the left limit to Boulder creek, a distance of about four miles. The gravels do not form a continuous stretch as they are cut across by Adams and Boulder creeks and various gulches, and separated into a number of areas known as Gold, Chechaco, Adams, Magnet, American, Orofino, Monte Cristo, King Solomon and Boulder hills. The gravel areas border the present secondary valley and extend back for distances varying from 800 feet on Magnet hill to 2,500 feet on King Solomon hill. The thickness ranges from a few feet up to 150 feet.

The volumes of gravel on the Upper Bonanza and Eldorado hills are as follows:

Bunker hill	1,050,000	cu. yds.
French hill	1,670,360	"
Gold hill	3,684,940	"
Chechaco hill	5,805,236	"
Adams hill	7,561,370	"
Magnet hill	485,672	"
American hill	2,210,888	"
Orofino hill	6,892,130	"
Monte Cristo hill	3,710,490	"
King Solomon hill	10,780,587	"
Boulder hill	1,475,216	"
Total volume	45,326,889	"

A paystreak varying from 200 to over 400 feet in width has been traced through all these hills. It is partly destroyed in places, but on some of the hills, notably on Orofino and Monte Cristo, it is situated some distance back from the present secondary valley and is entirely preserved.

The gravels in the paystreak of all these Upper Bonanza hills proved rich everywhere, and, in places, the values returned appear almost fabulous. Whole claims are reported to have averaged from $60.00 to $100.00 per square yard of bedrock. Portions of French, Gold, Chechaco and Magnet



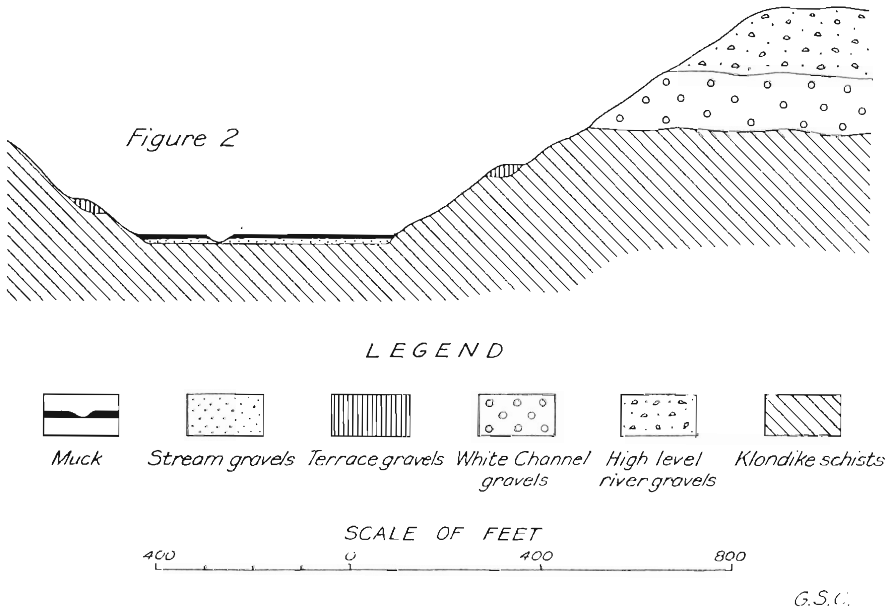


Figure 1. Generalized section across Bonanza valley below Eldorado Forks.

Figure 2. Generalized section across the lower part of Bonanza valley.

hills were particularly rich and yields of a dollar a pan, or $150.00 per cubic yard for the lower four or five feet of gravel, are stated to have been obtained from small areas on these hills.

The paystreak is now practically drifted out, portions of it twice over, and is estimated to have yielded gold to the value of $24,000,000.

Drifting operations, however, never result in a full extraction of the gold. A few pillars and occasional small areas are usually neglected for various causes; the bedrock is seldom thoroughly mined and no attempt is, of course, made to recover the values in the upper lean gravels. The paystreak gravels are also bordered as a rule on both sides by considerable fringes of gravel, too lean to drift but rich enough in most cases to hydraulic.

The gravels in the Upper Bonanza hills, considered rich enough to be hydraulicked at a profit, include all those in the original paystreak, those in a band behind the paystreak varying in width on the different hills from 100 to 200 feet and those between the paystreak and the present valley. The gravels in the back portion of most of the hills are too lean to be worked by any method.

The volumes of workable gravels on the various hills are estimated as follows:

Bunker	850,000	cu. yds.
French	570,360	"
Gold	1,779,650	"
Chechaco	3,752,914	"
Adams	2,379,000	"
Magnet	395,677	"
American	1,989,218	"
Orofino	5,533,000	"
Monte Cristo	1,853,150	"
King Solomon	4,681,087	"
Boulder	332,000	"
Total	24,116,056	"

The average values in these gravels are estimated at 34·05 cents per cubic yard and the amount of recoverable gold at $8,213,532. These figures are based on the results of the small hydraulic operations now in progress on most of the hills and on information obtained from private sources. The values are distributed so irregularly that it was considered a closer estimate could be formed in this way than by a limited amount of sampling done by ourselves.

Lower Bonanza Hill Gravels

Between Boulder and Cripple hills, a distance of three miles, the hill gravels bordering Bonanza creek are unimportant. A few small areas have been preserved at various points on both sides of the valley but these represent largely the lean rim gravels of the old deposit. The central portion containing the paystreak has been almost entirely destroyed.

Below Cripple creek pay gravels are again preserved on the benches, but occur on the right limit, the paystreak having crossed the valley. They extend through from Cripple creek to the Klondike valley, a distance of three miles, except where cut across by Trail and Lovett gulches. These gulches separate the gravels into three areas known as Cripple, Trail and Lovett hills.

Below Cripple creek the present Bonanza valley bends to the left away from the old valley and joins the Klondike some distance lower down. In consequence of this divergence only a small proportion of the gravels of the old valley on Trail and Lovett hills have been destroyed and the paystreak, except where cut transversely by gulches, has been preserved intact.

The volume of White Channel gravels on Lovett hill exceeds 71,000,000 cubic yards, an amount almost equalling the combined volumes on all the other hills bordering Bonanza creek. The deposit has a thickness in the centre of the channel of 168 feet and a width of 5,200 feet. It occupies a wide shallow depression in the Klondike schists and is overlaid and overlapped on both rims by 150 feet of younger gravels deposited by the Klondike river.

The White Channel gravels on Trail hill above Lovett hill have a thickness of 230 feet. They are overlaid in places by Klondike river gravels but are not completely buried as on Lovett hill.

The volumes of White Channel gravels and overlying Klondike gravels on the three lower Bonanza hills are as follows:

Cripple hill (White Channel gravels)	7,820,460	cu. yds.
Trail hill (partly Klondike gravels)	22,235,390	"
Lovett hill (White Channel gravels)	71,366,370	"
" (Klondike River gravels)	66,997,230	"
Total	168,419,450	"

These figures include all the White Channel gravels both in and off the paystreak, but only those portions of the Klondike river gravels which overlie the White Channel gravels and which would be required to be washed away if the latter were hydraulicked.

These lower Bonanza hills, although originally much lower in grade than the Upper Bonanza hills, are now almost as important economically, as they have been mined to a much less extent. The production to date is estimated at $750,000, mostly obtained by drifting.

The paystreak is remarkably wide and very uniform in grade. It is partially destroyed on Cripple hill but on Trail and Lovett hills where fully preserved has a width of from 1,000 to 1,400 feet.

The workable gravels are practically limited to the paystreak. The volumes are estimated as follows:

Cripple hill	White Channel gravels	614,910	cu. yds.
Trail hill	Mostly White Channel gravels	11,802,250	"
Lovett hill	White Channel gravels	23,503,770	"
	Overlying Klondike River gravels	14,511,760	"
		50,432,690	

The average grade of these gravels is estimated at 14·9 cents per cubic yard and the amount of recoverable gold in the three hills at $7,528,720.

The low general average, notwithstanding values of over a dollar per square foot of bedrock, is due to the exceptional thickness of the gravels over the greater portion of Lovett hill, amounting to fully 300 feet, of which the upper 200 feet are practically barren. The values in Cripple and Trail hills, and the rim portions of Lovett hill, considerably exceed the general average, while those in the central portion of Lovett hill are somewhat less.

Summary of Bonanza Creek workable hill gravels.

	Volume.	Estimated Values.
Upper Bonanza hills.......	24,116,056 cu. yds.	$ 8,213,532
Lower Bonanza hills.......	50,432,690 "	7,528,720
Total................	74,548,746 "	$15,742,252

Average estimated yield per cubic yard, 21.1 cents.

Total quantities of high level gravels along Bonanza creek.

Upper Bonanza hills (White Channel gravels)....	45,326,889 cu. yds.
Small hills between Boulder and Cripple hills not measured, estimated at..................	3,500,000 "
Lower Bonanza hills (partly Klondike gravels)....	168,419,450 "
	217,246,339

Hunker Creek White Channel Gravels

Bench gravels belonging to the White Channel period are extensively developed along Hunker creek but are much lower in average grade than those on Bonanza creek. They have been mined at various points both by the drifting and hydraulic methods with an estimated production up to the present of $2,500,000, the greater part of which came from Whisky hill, a small rich hill in the upper part of the valley. The generally inferior average grade of the Hunker Creek hill gravels as compared with those on Bonanza creek is due partly to their leaner condition originally, and partly to the fact that along the richest portions of the creek the paystreak of the old valley has been almost entirely destroyed and the gold contents washed down to the level of the present valley.

Upper Hunker Creek Hill Gravels

The White Channel gravels are first met with descending Hunker creek above No. 6 pup. The occurrence here is small and the gravels although workable are comparatively low grade. Immediately below No. 6 pup is the famous Whisky hill. A short stretch of the old paystreak has been preserved at this point. The upper and richer portion of the hill has been hydraulicked completely away with a production variously estimated up to $2,000,000 and probably approximating $1,500,000. The lower portion of the hill is only partially worked out and still contains 199,400 cubic yards of workable gravels. The gravels are shallow, averaging about twenty-five feet in depth.

The gravels of the old channel are destroyed for some distance below Whisky hill, but appear again on the left limit on Delhi hill above Goldbottom creek.

The Delhi hill gravel area is comparatively small, measuring about 136,000 square yards. The gravels have an average depth of about twenty-five feet and a total volume of 1,121,080 cubic yards. The workable gravels are estimated at 869,450 cubic yards. The values are moderate except along the rim, where a few small fragments of the old paystreak were preserved. Some hydraulicking is being done on the hill with water brought from Upper Hunker creek, and a second ditch to a point on Goldbottom creek is under construction.

Temperance hill immediately below Goldbottom creek is covered by a triangular patch of gravel extending up Goldbottom for a distance of 4,000 feet and down Hunker creek for 1,700 feet. The gravels are thin, seldom exceeding thirty feet, and averaging less than twenty-five feet in thickness. They are less compact than usual, and as a result of this most of the gold has settled down close to bedrock. The Temperance hill gravels measure altogether 1,590,580 cubic yards of which 788,750 cubic yards are considered to be workable.

Temperance hill has been a steady producer on a moderate scale since the early days of the camp, and is still of considerable economic importance. Some ground rivalling in richness that on the best Bonanza hills occurred along the rim at the junction of Goldbottom and Hunker valleys. This is now largely worked out but portions of the hill still contain good values, occasionally exceeding 50 cents to the cubic yard. The back gravels as usual proved lean. Three small hydraulic plants operating with water obtained from tributaries of Goldbottom creek are at work on the hill.

From Temperance hill down stream to Nugget hill above Hunker creek the central portion of the old high level channel, including the paystreak, has been destroyed. Portions of the rim gravels have been preserved at various points, some of which carry moderate values. An hydraulic plant has been installed to work two small areas below Bee gulch. These were estimated to contain 859,200 cubic yards of gravel.

At Nugget hill the paystreak of the old channel bends to the left and is again partly preserved. The upper part of the hill is lean but good values were obtained from the lower portions. The gravels are shallow, averaging about twenty-five feet in depth, and measure altogether 1,608,300 cubic yards. The workable gravels were estimated at 1,200,000 cubic yards. Nugget hill has been fairly well prospected but very little mining has been done on it owing to the difficulty of obtaining water. A small hydraulic plant is now in operation.

Summary of workable Gravels in upper Hunker Hills

Whisky hill	199,400	cu. yds.
Delhi hill	869,450	"
Temperance hill	788,750	"
Williams concession	859,200	"
Nugget hill	1,200,000	"
	3,916,800	"

Estimated average grade, 25.2 cents per cu. yd.
Total valuation, $988,000.

Hill Gravels between Hester and Last Chance Creeks

A wide band of White Channel gravel borders the left limit of Hunker creek continuously except when cut across by Eighty pup from Hester creek down to Last Chance creek, a distance of over two miles. The deposits of the old valley in this stretch were originally over a mile in width in places. They have been partially destroyed as the present Hunker valley has been sunk through them. The preserved portion on the left limit has a width of from 800 to 3,000 feet, an average depth of about sixty feet, and contains altogether 25,850,000 cubic yards of material. A few small areas occur also on benches on the right limit but are unimportant.

The upper portion of the gravel area on the left limit from Hester creek down to Seventy pup is known as Paradise hill, and is the most important stretch of hill gravels on Hunker creek, with the possible exception of Dago hill.

The Paradise hill gravel area has a length of 2,500 feet, and an average width of 1,500 feet. The gravels have an average depth of about sixty feet, and measure altogether, including the muck and slide material which cover them, on the back rim, 7,786,000 cubic yards. The workable gravels are estimated at 5,285,000 cubic yards.

The average grade proved somewhat difficult to determine on account of the exceedingly irregular distribution of the gold through the gravel and the absence of a satisfactory section across the paystreak. It is estimated at 23 cents per cubic yard, and the gold contents of the workable gravels at $1,215,500. This figure is based partly on mining returns and partly on a systematic sampling of all the available shafts and hydraulic cuts in the area. The best values occur in the upper part of the hill. Towards Seventy pup the gold diminishes both in quantity and coarseness.

Considerable mining, both by the drifting and hydraulic methods, has been done on Paradise hill, and two small hydraulic plants are now in operation.

The wide belt of White Channel gravels extending from Seventy pup to Eighty pup, a distance of 3,400 feet, is low grade everywhere so far as known. No definite paystreak has yet been located, although numerous shafts have been sunk for that purpose to bedrock throughout the area. The absence of a hill paystreak is somewhat remarkable as the bordering creek gravels are also lean, showing that it has not been destroyed. The gravels between the two pups have a depth in places of over a hundred feet and a total volume of 11,234,000 cubic yards. The gravels assumed to be workable include a small area below Seventy pup measuring 1,500,000 cubic yards, estimated at 13 cents per cubic yard, and portions of the rim gravels along Eighty pup. The latter are roughly estimated at 1,000,000 cubic yards, with a grade of 15 cents per cubic yard. The probable production of the hill is estimated at $345,000. No mining has been done on the hill.

Preido hill between Eighty pup and Last Chance creek is also comparatively low grade as a whole, but contains some gravels carrying good values in coarse gold on the Last Chance slope. The Preido hill gravels cover an area of 474,000 square yards, have a maximum depth of ninety feet, an average depth of forty-three feet and a total volume of 6,828,000 cubic yards.

The best values occur in a belt crossing the centre of the hill, 1,600 feet wide on the Last Chance slope and 1,100 feet on the Eighty pup slope. Samples from shallow shafts and hydraulic cuts along the Last Chance rim indicated an average grade of 35 cents per square foot of bedrock. Those obtained from the Eighty pup slope were much lower, averaging only 15 cents per square foot of bedrock. The zone defined above contains 3,093,530 cubic yards of gravel, estimated to average 15 cents per cubic yard, a total valuation of $464,000. This estimate is based on the assumption that the values obtained at the rims continue to the centre of the hill.

	Workable Gravels. cu. yds.	Values. $
Paradise hill	5,285,000	1,215,500
Hill between Seventy and Eighty pups	2,500,000	345,000
Preido hill	3,093,530	464,000
	10,878,530	$2,024,500

Average grade, 18.6 cents per cubic yard.

Last Chance and Lower Hunker Creeks White Channel Gravels

Dago hill below the junction of Last Chance and Hunker creeks is covered by a large and important body of high level gravels. The gravel area deposit has a maximum depth of 100 feet, an average depth of 68·5 feet and covers a triangular shaped area 862,000 square yards in extent. The total volume of gravels on the hill measures 19,639,000 cubic yards.

Dago hill is crossed diagonally by a well defined coarse gold paystreak, 3,700 feet in length and from 300 to 500 feet in width. The workable gravels have an estimated width of 600 feet (as the main paystreak is fringed with gravels carrying some values), and measure 6,423,000 cubic yards. The average grade calculated from the values obtained in sampling two sections across the paystreak is estimated at 19 cents per cubic yard.

In addition to the gravels on and bordering the main pay streak, portions of the rim gravels along Last Chance creek, roughly estimated at 750,000 cubic yards with a grade of 15 cents per yard, can probably be worked.

Total quantity of workable gravels, 7,173,000 cubic yards.

Estimated average grade, 18.6 cents per cubic yard.

Probable production, $1,332,870.

Last Chance creek is bordered on the left limit for one and a third miles along Dago hill by a number of small areas of rich hill gravels. Considerable mining has been done on all the areas and a couple of them have been worked almost completely away. The two most important areas at present are Treasure and Discovery hills. These still contain 2,173,000 cubic yards of gravel, estimated to average 24.1 cents per yard. Probable production, $524,000.

From Dago hill the White Channel deposit crosses the present Hunker valley to Australia hill, a small gravel-covered plateau separating Hunker creek from the Klondike river above their junction. The White Channel gravels on Australia hill cover an area of 1,586,000 square yards, have a thickness in places of over a hundred feet and a volume of 35,947,000 cubic yards. They are overlaid, as on Lovett hill at the mouth of Bonanza creek, by barren Klondike river gravels. The latter overlap the White Channel gravels on the Klondike river side. The portion resting on White Channel gravels has a thickness of 130 feet and a volume of 39,200,000 cubic yards.

Australia hill, although the largest both in extent and volume of gravels of all the Hunker hills, has so far proved of little economic importance. No definite paystreak crossing the hill has been located, and the chances are that none exist as the hill, apart from our own sampling, has been fairly well prospected. Coarse gold was found at one point near the mouth of Hattie gulch, and pay values are reported to have been found in a drift farther up the creek. The drift at the time of our visit was inaccessible. Samples from the rim near-by carried only light values. While some production may be expected from Hattie gulch, no definite statement in regard to the amount can be given. It is placed at $150,000, but this figure can only be regarded as a rough guess and may be largely exceeded.

Summary of Hunker Creek workable Hill Gravels

	Volume. cu. yds.	Values. $
Upper Hunker hills	3,916,800	988,000
Hills between Hester and Last Chance creek	10,878,500	2,024,500
Hills below Last Chance creek (exclusive of Australia hill)	9,346,000	1,856,870
Australia hill		150,000?
	24,141,300	$5,019,370

Estimated average grade (exclusive of Australia hill), 20.17 cents per cubic yard.

Total quantities of White Channel Gravels and overlying Klondike Gravels along Hunker Creek

		cu. yds.
Small hills above Hester creek		5,378,600
Hills between Hester and Last Chance creeks		25,850,000
Dago hill		19,639,000
Last Chance hills		2,950,000
Australia hill	White Channel gravels	35,946,770
	Klondike River gravels	39,200,000
Small hills, not measured, estimated at		3,000,000
Total		131,964,370

Klondike River High Level Gravels

High level gravels, usually at an elevation of from 200 to 300 feet above the valley flats, occur at various points along the Klondike river. These gravels differ altogether in character and appearance from the White Channel gravels of the creeks. The pebbles are smaller and more rounded, and consist mostly of slate, diorite and quartzite derived from the mountains of the Ogilvie range.

The Klondike river gravels as a rule carry only light values, but below the mouth of Bonanza creek they have been enriched and in places contain gold in commercial quantities.

The two most important areas of these gravels discovered so far occur on benches bordering the Klondike river at its mouth. These two areas contain approximately 4,780,000 cubic yards of gravel considered to be workable. The grade based on a somewhat hurried sampling of the various cuts and shafts is estimated at 20 cents per cubic yard. Probable production, $956,000.

General Summary of Probable Production of High Level Gravels

	Volume of workable gravels. cu. yds.	Estimated Values. $
Bonanza creek	74,548,746	15,742,252
Hunker creek	24,141,300	5,019,370
Klondike river	4,780,000	956,000
	103,470,046	$ 21,717,622

Low Level Gravels

The following estimates of the values remaining in the Klondike creeks are based mostly on data obtained from miners and others, as no satisfactory sampling of the creeks in addition to the hills in the time at our disposal was possible.

Eldorado Creek

The rich paystreak in Eldorado creek, originally the richest in the district, has been pretty thoroughly worked, portions of it twice over. Experience in reworking claims has, however, shown that few if any were completely exhausted. This has proved to be the case not only in drifted claims but in those which were worked by the open cut method. The old tailings are also expected to yield a considerable sum when resluiced. The Eldorado paystreak has a length of about four miles and its production up to the present is estimated at $25,000,000. The probable future output is placed at $2,600,000, an average of $65,000 a claim.

Upper Bonanza Creek

Upper Bonanza creek, the portion above Eldorado forks, proved rich up to Victoria gulch, a distance of about four miles. The paystreak in places rivalled that on Eldorado creek in richness, but the general average grade was considerably lower. It has been less thoroughly worked on the whole and at the present time the claims probably average somewhat higher than those on Eldorado creek. The past production is estimated at $15,000,000 and the future at $3,225,000.

Lower Bonanza Creek

Lower Bonanza creek has a length of about ten miles and is more or less auriferous throughout. The grade decreases as a rule down stream, but in an irregular manner, enrichments occurring at various points along the valley. Some of the claims a short distance below the forks proved very rich, and few unproductive claims occur from the forks down stream for seven miles. In the lower portion the valley flats increase in width, the gold is less concentrated and the gravels, except in a few places have not been drifted. Preparations are now being made to dredge them and it is believed that there are few, if any, claims on the creek which cannot be profitably worked or reworked by this method.

The irregular grade of the Lower Bonanza creek gravels has resulted in portions of the valley being well worked, while considerable stretches are still practically virgin and others are only partially worked. The production up to the present time, including that from the rich tributary gulches, is estimated at $11,000,000 and the future production at a minimum of $11,500,000.

Klondike River Flats

The Klondike river flats are expected to produce largely in the future. The work of the past season has led to the belief that the high level White Channel gravels of Bonanza, Bear and Hunker creeks originally extended for considerable distances out over what is now the valley of the Klondike and were destroyed during its excavation and the gold contents scattered along the river flats. Rich gravels have been found in the Klondike river flats below the mouth of all these streams. Evidence was obtained indicating that the destroyed portion of the old Bonanza high level valley was at least a mile in length. The destroyed portion represents the extension of the Lovett hill gravels and for some distance must have been equally as rich. Allowing for diminishing values down stream it is estimated that they contained gold to the value of at least $4,000,000 and possibly $5,000,000. The gold contents of the destroyed lower portions of the old valley gravels of Bear and Hunker creeks are roughly estimated at a minimum of $3,500,000.

Two dredges, one below the mouth of Bear creek and the other below the mouth of Bonanza creek, are at present working successfully on the Klondike river flats. The total production to date, partly obtained by dredging and partly by drifting and open cut work at the mouth of Bear creek, is estimated at $1,000,000.

Bear Creek

Bear creek is comparatively low grade compared with Bonanza or Eldorado creeks, but contained some rich ground near its mouth. It is estimated to have produced gold to the value of $1,000,000 and the probable future production is placed at $600,000.

Hunker Creek

The Hunker Creek gravels, like those of Lower Bonanza creek, varied greatly in grade along the valley.

A long, almost continuous, stretch of pay gravels extended from a point a short distance below Hester creek up stream for eight miles and occasional good claims have been worked for a further distance of two and a half miles. Most of the claims in the eight-mile stretch carried good values and some of them, especially around Discovery claim and in the thirties and forties below, were very rich. They have all been more or less completely worked, mostly by the drifting method. Lean ground commences below Hester creek, and with the exception of three claims below the mouth of Seventy pup, and a short stretch near the mouth of Last Chance creek, continues down so far as known nearly to Dago pup, a distance of three miles. Portions of the mile stretch between Dago pup and the mouth of the creek proved very rich. These lower gravels are probably the richest on the creek at present as they have been less thoroughly worked than the once rich stretches above Hester creek.

The production of Hunker creek up to the present, including that from the tributaries Last Chance, Hester and Goldbottom creeks, is estimated at $14,000,000, while the amount of recoverable gold remaining is placed roughly at $7,500,000. The data for this determination are more meagre than on the other creeks as little is known of the possibilities of the three mile lean and mostly unworked stretch above Dago pup. Light drifting values occur in places and it is probable that a considerable portion of it carries dredging values.

Summary of Estimated Values in Low Level Gravels

Eldorado creek	$ 2,600,000
Upper Bonanza (above the Forks)	3,225,000
Lower Bonanza	11,500,000
Klondike river flats	6,500,000
Bear creek	600,000
Hunker creek (with tributaries)	7,500,000
	$31,925,000

General Summary of Estimated Past Production and Probable Future Output of Eldorado, Bonanza, Bear and Hunker Creeks and the Klondike River, Hill and Valley Gravels

	Estimated past production.	Estimated future output.
Eldorado creek	$25,000,000	$ 2,600,000
Upper Bonanza creek	15,500,000	3,225,000
Lower Bonanza creek	11,000,000	11,500,000
Klondike river flats	1,000,000	6,500,000
Bear creek	1,000,000	600,000
Hunker creek	14,000,000	7,500,000
	$67,500,000	$31,925,000
Upper Bonanza and Eldorado hills	$24,000,000	$ 8,213,532
Lower Bonanza hills	750,000	7,528,720
Klondike river hill gravels	Small production.	956,000
Hunker creek hills	2,500,000	5,019,370
	27,250,000	21,717,620
Creek values brought down	67,500,000	31,925,000
Totals	$94,750,000	$53,642,620

This estimate of the amount of recoverable gold remaining in the various Klondike creeks and benches is based, as stated previously, on sampling done by ourselves, on the results of actual mining operations and on information obtained from various miners, and is believed to be a reasonably close approximation. It, however, only represents present knowledge, and no allowance is made or can be made for fresh discoveries of rich spots, the day for which, as shown by a recent find on Hunker creek, is not altogether passed, notwithstanding the thorough manner in which the district has been explored. While it is unlikely that any large area of rich gravel has escaped detection minor discoveries may be expected as long as mining lasts and on this account any estimate is apt to be somewhat under rather than over the mark.

Indian River Creeks

The estimate of values given above does not cover the whole of the Klondike district, as the creeks on the Indian river slope, including such important producers as Dominion, Gold-run, Sulphur and Quartz creeks, were not examined. These streams are estimated to have produced gold to the value of $24,250,000, making the total production of the camp to date $119,000,000. They have not been worked, on the whole, as thoroughly as the Klondike creeks, and the percentage of unmined gold is probably somewhat higher. A production of from eight to ten million dollars may still be expected from them.

The production of the Indian river creeks has been obtained mostly from the low level creek gravels. Bench gravels carrying good values occur at some points, notably along the central portions of Dominion and Quartz creeks, but their total yield has been relatively small.

1907

Introductory Note

In 1907 Mr. R. W. Brock was acting Director, and his notes in the Summary Report for that year on field work in the Yukon contain the following information:

R. G. McConnell was engaged in investigating the geology and economic futures of the copper-bearing rocks in the vicinity of Whitehorse. He was assisted by F. H. Maclaren, as topographical, and Mr. Haughton as geological, assistants. D. D. Cairnes continued his explorations in the southern part of the Yukon, chiefly between Whitehorse and Tantalus, where coal and copper were being developed. Joseph Keele was commissioned to make an exploratory investigation of a hitherto little known region situated for the most part between latitudes 62 and 63 degrees, but which also includes that part of the Yukon drained by the Upper Pelly and its tributaries, Hoole, Ross and Kitza Rivers.

"Mr. Keele, who is wintering in the Upper Pelly, writes that he can find no trace of the existence of an active volcano that prospectors, returning from this district, have reported among the mountains near the source of the Pelly."

REPORT ON PORTIONS OF THE YUKON TERRITORY, CHIEFLY BETWEEN WHITEHORSE AND TANTALUS

by D. D. Cairnes

This season was again spent in the Yukon territory, chiefly along the Lewes river between Whitehorse and Tantalus. I was again very ably assisted by Mr. H. Matheson, who did a considerable portion of the topographical branch of the work.

The Yukon territory was reached about May 25, by the usual route via Vancouver and Skagway, and those properties were first visited which had been worked on Windy Arm during the winter. After arriving in Whitehorse and completing the necessary arrangements, we left that town on June 1 and proceeded by canoe down the Lewes river towards Tantalus, having to remain, however, at the upper end of Lake Laberge a few days to allow the remaining ice on the lake to thaw or shift sufficiently for us to get through with our canoe.

Owing to instructions received during the latter part of the season to collect statistical information for the Mines Branch, geological explorations were somewhat curtailed.

The double object of the expedition included further surveys of the coal seams examined last year, some samples of which coked successfully in the laboratory, and of the copper deposits of the Whitehorse district, where successful working is largely dependent on accessible coal suitable for producing a metallurgical coke.

Discoveries of coal were reported at a number of points along Lake Laberge, the Lewes river, and its tributaries the Teslin and Big Salmon rivers. These were examined, as well as the geological formations, generally, along the river to Tantalus.

Except within a few miles of Tantalus, where the Tantalus coal measures cross the river, this so-called coal proved in most cases to be dark or black shales, sometimes more or less bituminous; in other instances the seams of coal, where they did exist, were only a few inches in thickness and of no present economic importance.

Areas Examined

Along the river to Lake Laberge, on the lake shores and westward for a few miles, none of the known coal-bearing horizons were met and no coal was seen. The formations here have a general northwesterly and southeasterly trend and the Tantalus coal measures were believed to extend in a southerly direction from Tantalus and to lie to the west of Lake Laberge. A map-sheet was therefore projected covering an area about ten miles wide in a north and south direction and extending to the west from Lower Laberge for a distance of about twenty-five miles. The coal measures lie just to the west of this map-sheet, but for the reason above mentioned the map was not extended far enough to actually include them.

From Lake Laberge the geological work was continued along the river to Tantalus, after which the auriferous veins and placer deposits of Livingstone creek were examined, as also the reported coal outcrops up Salmon river.

Having arrived at Tantalus another map was commenced which was intended to include the Tantalus and Five Fingers mines and the coal measures in their vicinity. Having completed the work along the river, packhorses were procured and the survey was continued to the south away from the river.

In addition to the above work quartz properties were examined in the vicinity of Dawson and on Williams creek which enters the Lewes river six miles below Yukon crossing.

Topography and Flora

The Lewes river between Whitehorse and Tantalus flows in a wide valley having a general north and south trend, and is extremely tortuous in most places, particularly below Lake Laberge, which is a portion of the river that has acquired considerable width and possesses very little grade.

The district examined this season is a typical representative of an uplifted plateau of erosion and is a portion of the Yukon Plateau province. To the west and east, particularly towards the north of the district, there is an abrupt change from one plateau to the mountain provinces of the Coast range and Rocky Mountain range respectively.

To the west of the lower end of Lake Laberge, and about 1,000 feet higher, the valleys, which often contain chains of lakes, are characterized by muskegs. The hills, as a rule, are mostly covered with underbrush and smaller timber, chiefly spruce, aspen and poplar.

To the north there is a particularly long chain of lakes which is drained for the greater part by Mandanna creek, a stream about four miles long that joins the Lewes from the south, nearly opposite Eagle Nest. The most southerly of these lakes, Frank lake, is over five miles long and has an average width of a mile. One branch of this chain continues west towards Montague on the Dawson-Whitehorse wagon road; the other branch continues about fifteen miles in a direction about SSE. The valleys of this portion of the country generally contain lakes of considerable size, and the hills, which are well rounded, are covered with small spruce, poplar, willow, and shrubbery of different sorts. Rock outcrops are very scarce.

Continuing down the river towards Tantalus the hills on the north slopes are chiefly covered with spruce and Banksian pine. Patches of poplar and willow are occasionally seen. The south slopes along the river are more open, some being quite bare; the little timber seen is chiefly poplar and willow. The country, farther back from the river here, and that just west of the river between Tantalus and Five Fingers, is practically all covered with spruce, Banksian pine, poplar, and willow, the greater part being spruce. The river flats generally support a growth of poplar, willow and a species of scrub alder.

Geology

From the upper end of Lake Laberge to Five Fingers the formations seen are similar to those in the more southerly portions of the Yukon. The oldest rocks exposed are Carboniferous limestones which belong in all probability to the Upper Câche Creek series. Above these are porphyrites, tuffs, tufaceous sandstones, shales, etc., corresponding to the Windy Arm and Tutshi series. Towards the north, however, the porphyrites, tuffs, etc., gradually give place to true sediments. Overlying these latter rocks are the coal-bearing Jurasso-Cretaceous beds, which are buried under more recent sediments and Tertiary flows of lava, etc. Intrusive granites, syenite-porphyrites, and porphyry dikes also occur.

Along the east shore of Laberge the rocks belong chiefly to the limestone series, although some of the more recent rocks, similar to those on the west shore of the lake, are found overlying these unconformably. Along the west side of the lake the rocks, which are chiefly bedded and dip at high angles, are generally coloured tuffs and tufaceous sandstones. These are either finely bedded or coarse greenish and massive. They are associated with dark, almost black, shaly rocks with occasional brownish bands. Heavy massive beds of very coarse conglomerate also occur, the contained boulders being often one to two feet in diameter. This whole series, lithologically, closely resembles the Tutshi series farther south.

South and east of Lower Laberge are some porphyrites, porphyries, tuffs, etc., closely resembling the rocks of the Windy Arm series and cut by dikes of typical syenite-porphyry. To the west the outcrops largely consist of coarse, massive beds of conglomerate, from 600 to 700 feet thick, the component pebbles and boulders being chiefly porphyries and granite. Underlying these are thinly bedded greenish and brownish sandstones and some dark coloured clays. This series is here seen to overlie the limestone series unconformably. Farther west, towards the Whitehorse-Dawson road, there are more tuffs and tufaceous sandstones and shales, generally quite massive, resembling those along the greater part of the west side of Lake Laberge. Outcrops are very scarce in this district.

From Lower Laberge to Hootalinqua the outcrops are chiefly limestone and rocks resembling the Tutshi series.

On the left of the Lewes river, just above Fife creek, conglomerates similar to those at the Tantalus coal mine occur for four or five miles. Though no coal was found here it will probably be discovered in the future. This was the only place at which this formation was noticed along the river until near Tantalus.

West of Salmon river an outcrop of the coast granite was seen, but the greater part of the outcrops here and along the Semenow range consists of generally greenish, fine-grained, and often quite calcareous porphyrites and tuffs. Below Salmon river these porphyrites, etc., continue to near Little Salmon, where true sediments commence. Below Little Salmon river to Tantalus practically all the exposures are limestones or other sedimentaries.

On the right limit of the Lewes river, below Little Salmon, the hills are conglomerate and sandstone to Eagle Nest, which is limestone. Just below, an almost perfect section of the sedimentaries occurring in this vicinity is to be seen unconformably overlying the limestone. Immediately above the limestones are the coarse massive sandstones like those causing the rapids at Five Fingers and elsewhere, and here called the Laberge conglomerate. Overlying these conformably is a series about 1,200 feet thick, which consists of dark shales and lighter coloured sandstones. The dark shale beds which are at times somewhat carbonaceous and contain small areas of lignite, comprise a considerable portion of this series. No lignite seams more than one to two inches in thickness were seen. In addition to these shales there are some thick beds of light gray, yellow and brownish sandstones, the light beds being soft, coarsely bedded and somewhat calcareous. They weather easily and are quite noticeable horizon markers. Some of the beds are more thinly bedded, harder and more siliceous. Remains of tree trunks are of frequent occurrence, particularly in the lighter coloured strata. This whole formation, with the exception of the dark shale bands, presents a coarse-grained, light-coloured appearance. Above this is a reddish series, in the lower portions of which are some narrow seams of lignite on which some prospecting has been done near Eagle Nest. Wider seams may yet be found. These reddish sedimentaries, which are generally coarse-grained, often thinly-bedded and quite calcareous, decompose readily by weathering. A heavy conglomerate bed of the same material occurs near the top of the series here. Though at least 200 feet were observed, the uppermost series were not seen in this section.

These beds in this section outcrop continuously along the river bank to within ten or twelve miles of Tantalus. Their strike is roughly parallel with the river, and the dips being away from the river the outcrop of the different beds shows an apparently horizontal stratification.

Nearer Tantalus are outcrops of the conglomerate formation, or beds, in which the coal at the Tantalus mine occurs. These conglomerate beds are here at least 500 feet in thickness; the top strata in particular shows distinct bedding, the beds being generally two to ten feet thick and very similar in appearance and composition. Chert, black quartz and slate pebbles, apparently derived from the Câche Creek beds, are the chief components. These conglomerates, though not seen in contact with any other formations, are considered to be probably the oldest sediments in the district. Overlying them are some massive, quite coarse, and very light-coloured sandstone beds somewhat resembling the coal conglomerates, but derived, apparently, chiefly from the coast granites.

Extending for several miles along the left limit of the river below Tantalus are basalt, melaphyres, etc., which are very recent and are associated and interbedded with some of the later sediments around the Five Fingers mine and elsewhere. These lavas, etc., are the newest geological formation in this district, except the glacial and postglacial silts, boulder-clays, etc.

Economics

In addition to the districts mapped this season, properties were examined in the following localities: Windy Arm, Livingstone creek, Dawson and Williams creeks.

Windy Arm

The only properties that have been working on Windy Arm, to any extent, since last season, are the Vault, Venus, and some of those controlled by the Anglo-American Consolidated Mining Company.

Owing to internal dissensions and other causes, the development of the properties on Windy Arm has been much retarded. In most cases the promising properties have continued to improve with development.

Owing to difficulties arising between the owners and the Anglo-American Consolidated Mining Company, work has been curtailed on the claims bounded by the latter.

On the Vault, which has been worked continuously for over two years, a long tunnel is being driven, but the ore had not yet been tapped when the mine was visited about October 1.

On the Venus, approximately 1,800 feet of work has been done this season, with the most promising results. A considerable quantity of ore is blocked out, and one hundred tons shipped to the Tacoma smelter this fall netted over $60 per ton after all smelting charges and deductions were made. The ore is a concentrating one and it is the reported intention of the company to erect a mill on the ground in the near future.

Livingstone Creek

A description of the geology and topography of Livingstone creek is given in Mr. R. G. McConnell's report and map on the 'Big Salmon Gold Fields', in the Summary Report of the Geological Survey for 1901. Since that time the old creek channel has been discovered and is being worked.

The gold is, or was chiefly in this preglacial channel. Since glacial times the present creek has been cutting farther and farther into the thawed south facing bank, the gravels on the north facing bank being frozen, so that now, above the canyon near the mouth of the creek, the old channel is on the left limit of the present creek valley. Near Discovery the two channels apparently coincide, and the present creek having the greater grade has worn down the older channel, into which it has concentrated its values. Above Discovery the gold is practically all in the old channel and is recovered by tunnelling from the present creek bed through the rock rim to the old channel and drifting on it. The pay on the old channel averages about thirty feet in width and two feet in depth, although it is considerably wider in places. There is quite enough grade to the creek for sluicing. The hillside claims, i.e., those on the old channel gravels, have produced, on an average, about $25,000 each.

About $90,000 was taken out of this creek last season and there will probably be over $100,000 taken out this season (1907).

Similar conditions exist on the parallel creeks, Summit Lake, Cottoneva and Little Velvet, but owing to scarcity of water only a small amount of work has been done on them. What has been done has given very encouraging results and it will probably pay to bring water from Mendocina creek or elsewhere.

Tantalus Mine

Since reporting on this property last season considerable progress has been made. The two main tunnels had, by August 1, 1907, been driven in over 1,800 feet, and twenty-three rooms had been opened up on No. 2 and eight on No. 1 seam.

Five thousand one hundred and seventy-three and a half tons of coal were shipped last summer, and it is expected that about 9,000 tons will be shipped this summer.

Tantalus Coal Measures

At Tantalus mine the formations dip to the east and on Tantalus butte, across the river, they dip to the west, showing the presence of a synclinal fold. The continuation of the eastern wing of this fold was noticed about a mile to the east of Tantalus on the left bank of the river. On account of heavy wash the coal is here not exposed, but a small amount of stripping should uncover the seams.

These measures, which cross the river at Tantalus, are known to extend in a northerly direction for several miles at least and in a southerly direction over fifty miles, crossing the Whitehorse-Dawson wagon road seventy miles from Whitehorse. In all probability they extend considerably farther. Throughout a distance of sixty miles they have been traced and wherever a section has been made two or more workable seams of good bituminous coal have been found. In the only places from which it has been obtained at a depth the coal cokes quite satisfactorily.

Tantalus Butte

At Tantalus butte and just across the river from Tantalus, only assessment work has been done. A section was examined this season and the following seams were measured and supplied:

		Feet	Inches
No. 1	Coal	0	7
	Shale	0	3
	Coal	6	1
	Shale	0	6
	Coal	0	10
No. 2	Coal	9	10
No. 3	Coal	8	10

Three smaller seams, fourteen feet, ten inches and six inches, respectively, were also measured.

All this coal is bituminous and of about the same quality as at Tantalus; when clean it yields a firm, coherent, coke, i.e., if obtained at a sufficient distance from the surface to be free from weathering.

Williams Creek

A number of claims have been staked this season on and near Williams creek. The Bonanza King, which was about the first staked and which was the only one on which any work had been performed, was visited in August. It is situated about one and one-half miles up Williams creek, a stream flowing into the Lewes river about six miles below Yukon crossing.

The ore is quartz, carrying chiefly the copper minerals bornite, chalcopyrite, and malachite. The vein is about six feet wide from wall to wall, including, in this thickness, one foot to two feet of the country rock. The ore is in a fissure, or fissures, in granite, near its contact with older, much altered diabase, now quite schistose in structure.

When seen, a shaft had been sunk about twenty feet on the ore and a tunnel had been driven about forty feet to cut the vein.

The ore is claimed to carry values in gold, silver and copper; however, average samples obtained by the writer gave only traces of gold and silver and 3·29 to 4·21 per cent copper.

Conclusion

The chief result of this season's geological work has been the locating of enormous quantities of available bituminous coal in this portion of the Yukon Territory. Full particulars, accompanied by contoured geological and topographical maps, will be published in the writer's detailed report.

REPORT ON A PORTION OF CONRAD AND WHITEHORSE MINING DISTRICTS*

by D. D. Cairnes

During the summer of 1905, Col. J. H. Conrad and others initiated development on Windy Arm, Tagish lake, Yukon, in consequence of which, Mr. R. G. McConnell, of this Department, on his way south from the White River district, made an examination of the properties. A short report of this examination was published under the title 'Recent Mineral Discoveries on the Windy Arm of Tagish lake'. The properties mentioned in that report having since been rapidly developed, the writer was instructed to make a geological and topographical map of the district and a report on the present aspect of the mineral prospects.

District Surveyed

Just after the Windy Arm district had been examined, considerable excitement was caused by the finding of quartz carrying free gold and telluride minerals between the Watson and Wheaton rivers, about fourteen miles in a direct line south-west of Robinson; within ninety days over 700 claims were located. It was seen that the district containing these claims, along with the Windy Arm properties and the coal areas south-west of Whitehorse, could be included in one map-sheet that would cover the then most interesting portions of the country in this part of the Yukon. The area lies for the greater part in the Conrad mining district, established this season. The south-east corner of the sheet, which accompanies this report, connects with the north-west corner of Mr. J. C. Gwillim's map accompanying his report on the Atlin mining district, B.C., 1901, and from this point the eastern boundary runs in a north-west direction to a point just east of Dugdale on the W. P. & Y. railway. The western limit of the map runs from a point on the British Columbia and Yukon boundary just west of Lake Bennett to a point about twenty miles west of Dugdale. The British Columbia and Yukon boundary is practically the southern edge of the sheet.

With the exception of a cursory survey, that employed a couple of days, the very interesting and valuable Whitehorse copper deposits which lie to the north of this map were not geologically examined, as detailed work in this locality would have entailed more time than was at the writer's disposal.

Method of Survey

Starting from a measured base on the W. P. & Y. railway, a few miles

* This report was published as a separate in 1908, Publication No. 982. (H. S. B., 1956.)

north of Caribou Crossing, a triangulation was carried through the district, connecting on the south with the Interprovincial Boundary and on the north with two of the stations of H. Dickson, D.L.S., who had determined their position from a point in Whitehorse. Latitudes were obtained with the sextant, and frequent observations were made for azimuth with the transit. The method chiefly adopted for filling in the topography was by transit, and vertical sketches to scale made from triangulation stations and other suitable points; the prismatic compass, micrometer, and aneroid being used for minor details.

Owing to the lack of time in which to make a complete micrometer survey of the rivers and creeks, these have all, with the exception of Watson river, been plotted from sketches. The railway, and the north and south portion of the Watson river, were plotted from the location line of the W. P. & Y. railway.

Transportation

This district is easily accessible. Steamers ply regularly between Seattle and Vancouver, and Skagway,—distances respectively of about 1,000 and 867 miles. From Skagway, Whitehorse, which is about 111 miles distant, is reached by the W. P. & Y. railway; thence, steamers run to Dawson, 460 miles. The railway has a general north and south direction, and at 20·4 miles from Skagway the summit of the White pass, which marks the boundary between the 'Panhandle' portion of Alaska and British Columbia to the north, is crossed. About thirty-one miles farther is the 60th parallel, the boundary between British Columbia and the Yukon. From the White Pass summit all the waters feed the Yukon river or its tributaries, the river having a general northerly trend for a considerable distance, eventually, however, turning toward the west and flowing into Bering sea.

Commencing about ten miles south of the 60th parallel the railway follows the east shore of Lake Bennett to its lower end, where it crosses, at Caribou Crossing, about sixty-seven miles from Skagway, a narrow strip of water connecting Lake Bennett and Nares lake. From this point, for about twenty miles, the railway follows the wide, open valley in which the Watson river flows, and soon approaches the Lewes river, down the west side of which it continues to Whitehorse, affording along the route a very good view of Miles canyon and the Whitehorse rapid.

The ores of the district are conveyed by aerial tramways to the shores of Windy Arm, whence they can be taken in boats up the Arm, and Nares lake to Caribou Crossing on the railway, a distance of about twelve miles. On the south shore of Nares lake, and the west shore of Windy Arm a railway, the building of which presents no more than ordinary engineering difficulties, would eliminate the present necessity of reloading at Caribou Crossing. A good grade for a railway also extends from Log Cabin via Whynton, B.C., to Conrad.

A government wagon road, about twenty miles long with very easy grade, was this season built from Robinson, a point on the railway about eighty-miles from Skagway, to Gold hill where the free gold quartz of the Watson and Wheaton Rivers district was first found. A similar road, about twelve miles long, was also built along the beach from Caribou Crossing to Conrad; and a third, built during the previous season, extends from Caribou Crossing to the Big Thing, one of the Windy Arm mining properties. Trails, mostly built by the Yukon government, have been run from the shores of

Windy Arm to and between all the most important claims. A road has also been constructed from Dugdale to the Whitehorse coal field, a distance of about twelve miles in a south-west direction, between which points a feasible railway route can also be found.

In fact, taking into consideration the railway already built, the suitability of the topography for further railway construction, the government built roads and trails, and the general natural advantages of the district, including the chain of lakes with their fiord-like arms, it may be said that transportation need be no bar to successful mining.

Climate

It is not very long ago that the popular conception of the Yukon was a region almost impossible of access, covered with perpetual snow and ice. Winter photographs, sensational newspaper descriptions of the Chilcoot pass, the building of the W. P. & Y. railway, and stories, generally exaggerated, of the hardships endured by those who joined in the early rush to Klondike, are mainly responsible for those opinions. It is certainly true, that from 1896 to 1898, when the influx to Dawson was at its height, great hardships were endured and many lives were lost, but when it is remembered that the majority of the gold seekers were accustomed neither to a mountainous region nor to encounter difficulties in northern latitudes; that prospectors frequently set out on their quest with only the vaguest notion of the route to be traversed; that the route chosen was often the worst possible in the circumstances, and that a large proportion of the travellers made the trip during the most unfavourable season, it is not amazing that there was loss of life, but that there was so comparatively little.

Now that the district has become better known, and railway and boat lines have been built, it is seen that the climate of the Yukon, and the southern Yukon in particular, (that dealt with in this report), is similar to that in many districts in British Columbia, and other northerly but prosperous mining camps of the world, and that few more difficulties have to be contended with in actual mining operations.

During the past season there was a considerable amount of rain on the higher summits, but in the valleys the weather was very pleasant. There was a moderate amount of rain and the temperature was similar to that experienced during other seasons in southern British Columbia. Added to this, however, is the delightful feature of the extreme length of the days; for a month or so there is little or no night, it never becoming completely dark. At least six months are suitable for surface working and for the necessary outside operations contingent on mining, and during many months work can be carried on by night, without artificial light, almost as well as by day. Frost, except in connexion with surface workings, does not interfere with quartz mining.

The district is very subject to high and long continued winds. On the summits these blow almost continually, and coming off glaciers and snow-capped peaks are exceedingly cold. The length and breadth of the valleys allow the winds a great sweep which makes the lakes, particularly Bennett and Windy Arm, very dangerous. Storms of terrific strength cause the almost smooth waters of these lakes to become rougher in a few minutes than, from their size, would be deemed possible. The wind dies down during the early hours of the morning, and remains calm until eleven or twelve o'clock;

sometimes, however, the waters continue rough for several days in succession, and as it is only possible, on account of their low temperature, to exist in them for a few minutes, an upset becomes an exceedingly dangerous matter and has brought disaster to even the best canoe men.

Flora

Except in some of the valleys—especially along the lower stretches of the Wheaton—and on the lower portion of the hillsides, no timber exists; even in the valleys the forest growth is very light. The lodge-pole pine (*Pinus murrayana*), the rough-barked poplar (*Populus balsamifera*), white pine, white spruce, balsam fir, and aspen comprise the existing species, with the exception of a growth of scrubby birch covering the slopes and higher valleys and often so thick as to be difficult to penetrate. The pine is found on the hillsides and in the dry valleys; the spruce in the swampy valleys, and the fir, frequently knotted and dwarfed, on the hillsides, near the timber-line. A saw-mill was in operation for a time on Mill Haven, but it is not now running.

The growing season for wild fruits is very short, but the almost constant daylight effects a continuous growth, so that the development of vegetation is surprisingly rapid. Mossberries, blueberries, and low-bush cranberries were plentiful; raspberries, gooseberries, and black and red currants were seen.

Game and Fish

Sheep are numerous a few miles west of the railway, and, except where they have been hunted, are not particularly wild or difficult to obtain. Large flocks, of a species considerably lighter in colour than the ordinary Rocky Mountain sheep, were often seen feeding on the hillsides.

Caribou and moose were plentiful in the western portion of the district. Black bear are common, and the grizzly bear is found. Beaver dams and beaver cuttings, often quite fresh, were frequently met, chiefly along the Wheaton and Watson rivers. Ptarmigan were seen in large numbers on nearly all the higher ridges and summits, and rabbits were quite numerous. Grouse of different kinds were less often seen, and ducks and geese only occasionally.

Topography

General

This district occupies a position along the western edge of the Central Plateau region, or, more particularly, the Yukon plateau, and just east of the Coast range, which consists of bare granitic mountains. Although in northern British Columbia and southern Yukon there is no sharp line between the plateau and mountain provinces, there is, north of the district here considered, an abrupt change from one to the other.

Viewed from the summits, this Yukon Plateau region appears as a gently undulating plain, broken only by occasional peaks and ridges that have withstood the general erosion. Near the Interprovincial Boundary the plateau has an average altitude of about 5,000 feet near the western edge, slopes gradually towards its centre and, in all probability, rises again towards the east to meet the Rocky Mountain system. It also becomes gradually lower towards the northwest. This upland plateau province is one of erosion and not of constructive deposition, and into it the drainage courses have cut valleys from 1,000 to 4,000 feet deep, the result being a very irregular topography, the summits of the unreduced ridges and mountain masses dividing the different waterways. The valley of the Lewes river, near its source, is cut down to depths of about 3,000 feet below the general level of the plateau (5,000 feet), but as the general gradient of the river is about the same as the general slope to the northward of the plateau, there is little change in the relief to the north of the district included in this report. This plateau was formerly at a lower elevation, and, with the exception of the unreduced portions, which now form the irregular peaks and ridges of its province, was reduced practically to base level, forming a plain sloping towards the north and west. A subsequent uplift gave the rivers and streams renewed life and sufficient activity to begin cutting down their present channels. The flat-topped hills and uplands, separated by these newly-incised valleys, are particularly well developed northward from the West Farm of Lake Bennett.

A broad valley up to seven or eight miles wide, floored with silt deposits, and marking an abandoned waterway, extends from the lower end of Lake Bennett to within a few miles of the Whitehorse rapid, affording a natural pass for the railway.

The Yukon river, the fifth largest on this continent, rises in British Columbia, just south of the 60th parallel, and lies, generally speaking, in about the middle of this Yukon plateau. The valleys of the lakes at its source appear to be chiefly formed by glacial action and by being dammed in places by great deposits of drift material. It may be presumed that these lakes, in general, mark the positions of the tongues of the great glacier which, towards the last, disappeared so rapidly that there was not sufficient time for the lake beds to be filled with glacial material. Tagish lake, in particular, is very irregular in outline, being part of a flooded valley system.

The two chief, and, in fact the only rivers in the district are the Wheaton and Watson, which flow into Lake Bennett. Portions of these, particularly near their mouths, are still cutting channels through the silts and glacial materials of the glacial period, and are, in consequence, characteristically tortuous.

The district may, in a general way, be described as consisting of groups and ridges of mountains separated by wide valleys often occupied by lakes, and running in a north-west and south-east direction, or about parallel to the western edge of the plateau region, which, like the Coast range, follows the coast line not only through the United States and British Columbia, but also into Alaska.

These valleys interlock at times in an intricate fashion. The district here described, although, like the mountains, extending in a north-westerly direction, embraces, in its northern area, a portion of the plateau country, and consequently is here more rolling and less rugged.

Windy Arm District

The district referred to in this report as the Windy Arm district, which occupies a position at the contact of the plateau and mountain region, consists of a high and rugged group of mountains rising from 4,000 to 5,000 feet above the lake levels, and lies immediately to the north of the British Columbia and Yukon boundary, between Lake Bennett on the west and Windy Arm on the east, and south of Nares and Tagish lakes. The rugged mountains along the southern edge of this district rise, for about five miles north of the 60th parallel, very abruptly from both sides of Windy Arm. To the north of this, on the west side of the Arm, the hills gradually become lower and slope somewhat gently from the beach. The mountains on both sides of Lake Bennett are also high and rugged, becoming more so farther west. This district is surrounded on three sides by deep-cut glacial valleys; on the east and west sides the streams have, in all cases, hanging valleys of varying heights through which they flow with a gentle and even slope until the eroded valley is reached, when they drop abruptly through canyons and gorges, generally over, as in the cases of Pooly, Montana, Dundalk and Knob creeks, a succession of falls, to the main valley below.

North of Nares Lake

These mountains, about eleven miles average width, extending for six or seven miles north of the lake, are high and rugged, having an average altitude of 3,700 feet above the lake itself, though Mt. Caribou rises about 600 feet higher still. The greatest heights are attained some three to four miles east of the railway. Mt. Wounded Bull, four miles east of Robinson, is 4,350 feet above the lake level—or 4,000 feet above the railway— but between this mountain and Mt. Caribou the hills are lower and more broken, while to the north they gradually become less and less, and disappear at the banks of the Lewes river.

Mount Gray Ridge

Between the Watson and Wheaton rivers rises a prominent feature in this section, the Mt. Gray ridge, whose summits reach some 4,000 feet above the level of the lakes. This ridge, about seventeen miles long, is characterized by very abrupt slopes and escarpments along its western edge, which is remarkably straight, in a direction somewhat west of north. It affords a particularly striking example of glacial action in the main valleys. The eastern side, though wooded to some extent, is for the most part grass-covered, and slopes gradually to the valley below.

North and West of Mount Gray Ridge

The Wheaton river, for about fourteen miles from its mouth, flows in a direction slightly east of south; above this, however, its course assumes an easterly direction. To the west of the lower portion of the stream the hills in regular relief gradually rise, along their eastern edge, to average heights of nearly 6,000 feet above sea level. Still farther west there opens out a level or undulating plateau of about the same elevation.

This plateau feature continues with varying regularity in a north-west direction to the north of the Wheaton river, in fact to near the northern edge of the map-sheet.

North of Robinson and west of the railway the hills are low and rolling, typical of the country of the plateau province. The first mountain of any prominence at all close to the railway is the somewhat cone-shaped and grass-covered Golden Horn, 5,610 feet above sea level. West and south-west of it the topography is characterized by rounded hills with very gently sloping sides; west of this again, towards Mt. Granger, 6,850 feet above sea level, the country becomes more rugged and rocky, but the eastern edge of the range proper is here again approached.

Valleys

These different ridges or groups of hills are separated as described above by deep, wide valleys, which probably correspond with the valley systems of the region before the last period of uplift, and which are now, in places, occupied by lakes or rivers, and which in many cases, especially where not occupied by the larger lakes or rivers, contain muskeg. Muskegs are also often found high upon the hillsides and in the high passes between the hills. In the valley between Mt. Needle and Mt. Folle, partially occupied by Annie lake, is a somewhat wide and dangerous swamp. This portion of the valley, a continuation of the Wheaton River valley to the south, has become blocked by glacial material which in time will be carried away, when much of the water now being carried to Lake Bennett by the Watson river will flow down the Wheaton.

Economic Geology

General

Although numerous claims have been staked in this district, quartz mining, except some development work on the copper properties just west of Whitehorse, was almost unknown in the Yukon until the latter part of the season of 1905, when Col. J. H. Conrad initiated work on the Windy Arm properties. Since that time a great deal of work has been accomplished.

In other parts of this report will be found details regarding the actual amount of mining development that has been done, the construction of aerial tramways, and the building of roads and trails to and between the different mining properties. The little town of Conrad has sprung into existence, and prospectors have been encouraged to do more prospecting, with the result that a number of promising properties have been discovered. A great many men have been employed, the mineral resources of the district are in a fair way to being developed, and what promises to be a permanent industry has been established. The commencement of the work on these Windy Arm properties, therefore, marks an important era in the history of the district, even though the properties in question are all, as yet, in the development or prospect stage.

The whole southern part of the Yukon was formerly included in the Whitehorse mining district, but this summer became of sufficient mineral importance to warrant sub-division, and the Windy Arm portion, including most of the Watson and Wheaton Rivers district, is now included in the Conrad mining district, with a recorder's office at Conrad.

In opening up these properties a great many difficulties had to be overcome. Most of the claims are situated high on the mountain sides, and all supplies, provisions, and even the wood for fuel and timbering had to be packed up on mules and horses. To haul up machinery of any kind was very expensive. Now, however, most of the timber and supplies are carried up by aerial tramways. The rigours of the winter, and—high up on the hills—even those of the spring and fall, have to be considered. Moreover, it was difficult to get men to work who could be called miners. The ordinary wage paid is $3.50 per day of eight hours, with board and lodging.

A telephone system connects the different camps with Conrad and Caribou Crossing. A telephone will be found at practically every claim where anyone at all is working. This great convenience is very cheaply installed, and facilitates work in many respects. There are also small gasoline launches on Windy Arm useful for making quick trips around the lake. The *Gleanor*, which is quite a large steamer, runs twice a week between Caribou Crossing, Atlin, B.C., Conrad and Whynton, B.C. A number of other steamers and small boats are in use on Windy Arm and in the vicinity.

Windy Arm Properties

Beginning with the Windy Arm district, some of the important properties going southward are the Big Thing group, the Montana, Joe Petty, Aurora, Thistle, Uranus, M. & M., Vault, Venus No. 1, Venus No. 2, all owned by the Conrad Consolidated; the Ruby Silver, owned by private parties; and the Venus Extension, Beach, Red Deer, and Humper No. 1, owned by the Anglo-American Consolidated Mining Company.

Big Thing. A wagon road from Caribou Crossing, and trails from Conrad, and from the upper terminal of the Montana tramway, have been built to this property, which is situated about five miles in a north-westerly direction from Conrad, and differs from all the other properties in this district, having granite for its country rock. The quartz veins of the others are in true fissures in the porphyrite, etc., of the Windy Arm series. The principal vein on the Big Thing was struck this summer at the end of an 80-foot drift. A cross-cut was then run sixty feet on the ores, and a winze was sunk which was about fifty-five feet deep at the time visited last, early in October. The vein, which dips into the hill, was widening rapidly in the bottom and becoming almost flat. It was about ten feet wide and appeared to be of the elongated lense type. The gangue is chiefly quartz and is very porous near the surface, showing the effect of considerable leaching action. The associated minerals are chiefly oxides and carbonates, which should change to the sulphides, etc., at a moderate depth. Stibnite, arsenopyrite, and pyrite were found near the bottom of the shaft. High assays are occasionally obtained in gold and silver, and it is claimed that the ore body will average close to $30.00 per ton.

The Montana is situated about four miles south of the Big Thing and, like it and most of the Windy Arm properties, is high up on the bleak mountain side. A $90,000 Riblet aerial double cable tramway runs from the northern extension of the Montana, the Mountain Hero, to Conrad, a disdistance of 18,697 feet, and has its upper terminal 3,464 feet above the lower. This tramway was built to the mouth of a cross-cut tunnel started on the Mountain Hero, and was intended to tap the Montana vein at a considerable depth, but ore has not as yet been struck in this tunnel. The tramway was commenced about the same time as the tunnel, and it is somewhat unfortunate that it was completed before the most favourable point for its upper terminal was known. During the past summer, however, supplies, timber, and fuel were sent up very cheaply, not only for work in the Montana and Mountain Hero, but also for the Big Thing, Aurora and Thistle, so that a considerable saving was effected. Waste rock from the dump was sent down the greater part of the time to keep the tram running. The tramway will continue to carry up supplies and to bring down the Montana ore from the Montana workings, and any other claims in the vicinity.

A gasoline engine was installed on the Mountain Hero this summer to operate a compressor to run the machine drills used for a time in the Mountain Hero tunnel. The compressor was placed on a prominent point on the side of Montana creek just below the tunnel, so that water power would be available to run it during certain seasons of the year. Stone houses have been built here as well as on the Big Thing for offices, bunk houses, and cook houses.

A drift was run about 700 feet on the vein, which has a strike of about N. 43° W., and dips to the south-west at 10° to 15°. The gangue of this vein is similar to that of the other properties of this district, i.e., mainly quartz in a fissure in the porphyrite—large interlocking crystals being very characteristic. The vein is from two to five feet in width, with a streak of rich ore, eight inches to eighteen inches wide, next the hanging-wall. This richer portion is reported to assay about $90.00 but the average of the vein is much lower and is said to run $20.00. An incline is being run on the ore and about the first of October, when last seen, at a depth of 320 feet, the lode was about eight feet from wall to wall with, however, over four feet near the centre of almost barren, leached, and somewhat decomposed porphyrite streaked with quartz stringers.

The values are mainly in silver, the chief mineral being galena. There were also found native silver, lead carbonate, argentite, pyrargyrite, tetrahedrite, pyrite and arsenopyrite. Some ore shipments have been made to outside smelters.

Trails have been built from this mine to the Big Thing, Conrad city, the Aurora, Thistle, Vault, Uranus, Joe Petty and Venus.

The *Joe Petty* is situated on the north side of Pooly creek about 2,800 feet above Windy Arm, and has a strong vein about six feet wide composed of alternating layers of decomposed iron-stained quartz and mineralized country rock. A shaft has been sunk about fifty feet and drifts have been run each way. A forty-foot tunnel has also been run with drifts at the end. No work was done on the property this season.

The *M. & M.*, to the east of the Joe Petty, has a narrower vein—twelve to fifteen inches wide—which is high grade ore and can be traced for a considerable distance. The rich silver minerals, argentite, pyrargyrite, and stephanite, were seen here.

The *Uranus* is situated immediately across Pooly creek from the Joe Petty and just above the upper forks of the stream.*

A tunnel has been run in on the south side of the main creek to crosscut the vein, which has not been struck as yet. Farther south on the other side of the hill and on the north side of the south branch of the creek a tunnel has been driven 180 feet on the vein, which varies in width from one to four feet. An upper tunnel was also started this summer on the north side of the south branch of the creek where the vein has a width of three and a half feet, but owing to difficulty in regard to contracts was only driven a short distance.

On the *Thistle* and *Aurora*, higher up the creek, above the Uranus and Joe Petty, and over 3,000 feet above Windy Arm, prospect work was carried on the greater part of the summer, and some very rich ore was reported. The ore is chiefly quartz, carrying chalcopyrite, zinc blende, malachite, and stephanite.

The *Vault* is situated on the south side of Pooly canyon about 2,000 feet above, and about a mile from the beach. When last seen (October) a drift on the vein was in about 325 feet, and a lower tunnel had been started for

* On Mr. McConnell's sketch map of this district he has named the main branch of the creek Uranus creek, and the canyon below the forks, Pooly canyon. In his report accompanying the map he speaks of this main branch as Pooly creek. Pooly being the older name, the main creek, including the middle branch, or the above-mentioned Uranus creek, will be referred to as Pooly creek, and the other two branches the North and South branches respectively.

which a 300 feet contract had been given. This, the same lode, in all probability, as the Venus, can be traced for a considerable distance. It is in places twenty to twenty-three feet in width and is nearly all well mineralized quartz. In places there are four to six feet of almost solid galena. The vein here, as on the Venus, varies greatly in width, and at times is not more than a foot or so broad, but on the Vault so far, except at the entrance to the tunnel, its character and ore values are fairly uniform. An aerial tramway to the beach is under construction, and a shorter one spans the canyon for the transport of wood and supplies.

Situated as this property is, in Pooly canyon, whose walls rise apparently almost perpendicular, for hundreds of feet, work was for a time carried on under many difficulties. Wood and supplies were packed up from the beach to the head of the canyon, and then down to the Vault over a trail cut out along its sides. Even a place large enough for a small tent had to be blasted out of the sides of the canyon. Now, however, the tramway carries over the wood and supplies, and quite comfortable frame bunk and cook houses have been built, in addition to a building at the mouth of the tunnel that serves for blacksmith shop, etc.

Venus No. 1. On this property, which adjoins the Vault on the south, a shaft has been sunk on the vein for fifty-two feet, and drifts running each way prove the quartz, which was only about ten inches wide at the surface, to have opened out nearly three feet. Several feet of iron-stained, fissured, mineralized rock lie next the quartz. Fifteen tons of ore shipped to an outside smelter, it is stated, have averaged sixty-five dollars per ton in silver.

Venus No. 2 lies south of and adjoining the Venus No. 1. A cross-cut tunnel was put in about one hundred feet to the vein which dips to the west into the mountain, and drifts were run about the same distance each way. Some stoping was done, the lode being eighteen inches to sixteen feet in width. In the stopes there is four to eight feet of good ore which will average over $20.00 in gold and silver. A lower cross-cut succeeded by drift in each direction, has also been run 544 feet to the vein, which is narrower and leaner than in the upper tunnel, but the narrowing is unlikely to be very extensive as the vein looks well for a few hundred feet both to the north and south.

The chief minerals are galena, lead carbonate, arsenopyrite, chalcopyrite, malachite and pyrite, while a considerable amount of jamesonite and antimony ochre occurs. The ore is chiefly argentiferous galena. Where the vein is wide it consists of alternating bands of quartz, and mineralized country rock. Some ore has been shipped to outside smelters from this property, mostly in the nature of test shipments.

A fifty horse-power gasoline engine operates a compressor here to run the machine drills used on this property, but water-power from Pooly canyon is being installed. An aerial two-bucket tramway 1,525 feet long runs from the lower Venus tunnel to the beach, the upper terminal being 958 feet above the lower. The engine house, bunk, and cook houses, are situated on the beach below the mine workings.

The *Ruby Silver* claim lies to the west of, and adjoins, the Venus No. 2, and has produced some very rich ruby silver ore. The vein is from three to eighteen inches in width.

On the *Venus Extension* adjoining the Venus No. 2 on the south, are two veins about thirty feet apart which can be traced right across the property, and practically up to the upper workings on the Venus No. 2. The upper vein apparently corresponds to the Venus vein; the lower one is probably an off-shoot from it that has not been discovered on the Venus ground. The upper vein contains about four feet of good ore, over half of which was being sacked in October. The sacked ore will probably run $50.00 to $60.00 per ton. An incline, sunk on the ore, was down about forty feet. The lower vein contains about two feet of ore, chiefly argentiferous galena with a considerable amount of arsenical iron and pyrite.

The *Beach* claim, lying to the south of the Venus extension and separated from it by the Nipper fraction, is supposed to be on the same vein as the Humper No. *1*; it has over ten inches of ore, claimed to average about $150.00 in silver, and probably $5.00 in gold. The chief minerals are galena, argentite, zinc blende and pyrite.

The *Red Deer*, lying to the west of and adjoining the Venus Extension, has in places about six inches of almost solid galena, which is reported to run over $90.00 per ton.

The *Humper No. 1* is a very promising looking property overlooking Windy Arm from a height of about 2,200 feet. It adjoins the Beach claim to the south-west. Only about seventy feet of work in the form of drift had been done. The vein, which strikes almost true east and west, and dips at about 45° to the north, is from eighteen inches to four feet in width and carries argentite, ruby silver, and stephanite, with some native silver, galena and pyrite. About eight inches of the vein are said to average over 300 ounces in silver, and a narrow streak of argentite half an inch to three-quarters of an inch thick, which is quite persistent, is said to give 3,000 ounces of silver. Some small, but high grade shipments of a few tons each have been made from this property and others of the Anglo-American Consolidated Mining Company.

From what could be learned in the examination, all these Windy Arm deposits have the same general characteristics and have been produced by the same causes. They are all mineralized quartz veins in true fissures, the crystals being generally large and interlocking to some extent, but in a general way pointing to the centre, showing the growth of the veins. Ascending thermal waters have probably been chiefly accountable for the deposits. The systems of fissures consist of main lines, with secondary parallel ones, with a certain amount of replacement between the different fissures of country rock by minerals. Some of the walls showed much slickensiding, indicating that the fissures are fault fissures. In these cases the ores are more liable to be persistent, and to continue to greater depths, than if the fissures were merely minor breaks due to cooling or tension, etc., without the walls having been pushed over one another, and thus generally indicating a more extensive disturbance and consequent fissuring.

Besides these properties some native copper is found on the east side of Windy Arm in an augite porphyrite, and appears to have been deposited in seams and in little patches very similar to the occurrence noted by Mr. J. C. Gwillim in the Atlin district. However, so far, it has not been found in workable quantities.

Some work was done this summer on the Rams Horn on the east side of Windy Arm, and very good looking quartz ore carrying galena, zinc blende, chalcopyrite and pyrite was seen there, but the veins examined were too narrow to be profitably worked.

West of Lake Bennett and on the east side of Mt. Gray some work has been done on the College Green. This claim is one of four located along a band of lime about fifty feet wide, and running in an easterly direction to the shore of the lake. Copper minerals, chiefly chalcopyrite, are found along this line which occurs in the porphyrite formation, and on the College Green, where it probably looks the best, the ore occurs in irregular bunches and veins. Further work here might disclose a workable body of ore.

The ore values given in this report were obtained from a number of samples taken, and also from assay returns kindly shown the writer by mine managers, superintendents, prospectors, and others during the season.

Watson and Wheaton Rivers Claims

Reference has been made to the excitement caused this season by the discovery, made between the Watson and Wheaton rivers by D. Hodnett and J. Stagar, of quartz carrying free gold and telluride minerals. The first claim staked was the Gold Reef on Gold hill on June 21, about fifteen or twenty miles south-west from Robinson, and, as has been said, within the next ninety days over 700 claims were located.

A belt of schists, approximately half a mile wide, outcrops in a north-westerly and south-easterly direction near the eastern edge of the granite formation, both schists and granites being cut by dikes of greenish porphyry and porphyrite. It is in this disturbed belt that the quartz veins occur, either in true fissures in the granite or between the planes of schistosity of the schists. These veins are often well mineralized, the chief minerals being galena with occasional gray copper, chalcopyrite, and pyrite. Outcrops of quartz, very much resembling each other, are seen in almost parallel lines, at short intervals, and with the same general strike from the Watson river to about eight or ten miles south of the Wheaton river—a distance of about twenty miles. Although most of the veins found were in this belt, only about two miles wide, Mr. Porter and others discovered, towards the end of the season, some large deposits of pure stibnite and other minerals at a considerable distance west of the belt. Details regarding the geology of these deposits are included in the geological portion of this report.

The first discoveries were made on Gold hill, Mt. Hodnett, and Mineral hill, all in the line of strike of this belt and just south of the Watson river. One vein of solid quartz is, for long distances, ten to fourteen feet wide and, in places, is fairly well mineralized with galena, argentite, chalcopyrite, malachite, and pyrite. In the vein traversing the Gold Reef, which is in the schists, is well defined on the surface, and which appears to be four or five feet wide, a pocket or streak of very rich ore was found carrying coarse free gold and the rich telluride minerals sylvanite, hessite and telluric ochre. Further work on this claim, however, failed to disclose any more of the rich ore.

A group of claims, the Custer, Alice M. and Ramon, staked just south of the Gold Reef on a gray copper vein, looked somewhat promising, although no work had been done when seen. The width of the vein was difficult to define, on account of wash and slide rock, but it is probably about six feet and appears to be well mineralized.

The *Legal Tender*, staked by J. Perkins, lies to the north-west of this group and is on a very steep, rugged, side hill on the south bank of the Watson river. The vein is, in a fissure in the granite, where exposed, three to three and a half feet in width, and consists of quartz carrying argentiferous galena with some chalcopyrite, malachite and pyrite. The values are chiefly in silver and are claimed to average about $40.00 per ton.

On the Big Bend mountain, to the south of the Wheaton river and seven or eight miles south-west of Gold hill, and in the line of strike of the mineral belt, a number of claims were staked by L. Belnew, O. Dickson, J. Perkins, and others on well defined quartz veins in the granite; they carry galena, chalcopyrite, pyrite, etc. South-west of this, in the same direction, on Mt. Stevens, the veins in the granite were again found and most of the outcrop was staked—Messrs. Stevens, Hogan and partners doing the first staking. On the hill to the west a number of similar looking locations were made by Messrs. Gilliam and partners on quartz veins in the schist carrying galena and chalcopyrite. In fact this whole belt, from one-half to two miles wide, was practically staked from north of the Watson river to west of the north end of Mill Haven—a distance of about twenty miles—and naturally a great many valueless locations were made, though several have good surface indications.

Assays running as high as $300.00 or over were occasionally obtained, as also a number of fairly average assays from $20.00 to $60.00, but with the exception of a small amount of work performed on the Gold Reef, no real development has been attempted.

But there is a large amount of mineralized quartz in this section of the country and, considering the little prospecting accomplished, the results are very encouraging, and should stimulate both prospectors and capitalists to investigate this belt more closely, following it to the north-west and prospecting on its western limits.

Coal was found about two miles to the east of Gold hill, at the same horizon as that in the Whitehorse coal fields to the north, but whether it is in sufficient quantities to be of economic value remains to be seen.

Union Mines

A group of four claims, known as the Union Mines, is situated on the hills just to the west of Annie lake, about nine miles due west of Lansdowne siding and about three or four miles east of Gold hill. These claims were first staked by W. F. Schnabel in 1898, and are supposed to cover the ground known as the Lost Mine. Some work has been done on the properties and preparations are being made to continue development during the winter. A ten ton shipment of ore, Mr. Schnabel informed the writer, gave returns of over $20.00 per ton. The values are chiefly in silver and a little gold.

As these claims are, in all probability, the first staked in the southern Yukon, their history is somewhat interesting. The writer obtained the following information, chiefly from Mr. Schnabel.

In 1893 Thomas Kerwin and two others staked claims in this vicinity, and took out ore which assayed $1,200.00 and over to the ton. Kerwin died and, later on, while lying on his death-bed in Juneau, Alaska, Kerwin told the Catholic sisters of his discovery and willed his interests to them. He described approximately the place, maintained that his old camp would be found on a creek near which a pick, driven into a tree, had, hanging on it, a shovel and coffee pot. After considerable searching Mr. Schnabel and others coming in by Lake Bennett and the Wheaton river found this old camp, as described, but could not find the ore. However, the veins of the present Union mines were found on the hill just to the north of the camp and were staked in 1898. They were held more or less continuously until 1903, when the four claims now held were staked and have since been the property of Messrs. Schnabel, Follé and partners. Mr. Schnabel showed the writer an old original location notice signed by Kerwin and partners, which was wrapped up in a piece of oil cloth and was found in a crack in an old post on the ground of the present mines. The owners who have built cabins and cut trails, besides doing considerable prospecting in the vicinity, still expect to find the rich ore of this Lost Mine on their ground.

Whitehorse Coal

Several seams of anthracite coal, on which a number of claims known as the Whitehorse coal claims have been staked, outcrop along the north side of the pass (2,000 feet above the railway at Dugdale) at the head of Coal creek, about twelve or fourteen miles in a southerly direction from Dugdale. A tunnel about sixty feet long has been run on one of these seams and a few open cuts have been made; otherwise the coal is entirely undeveloped. The strike at the tunnel is true north 63° west with 42° dip to the north-east. The general strike of the measures—which were traced over twelve miles—is about north 74° west. The seams measured were nine feet eight inches, ten feet four inches, and two feet six inches respectively. Numbers of other seams may exist and probably do, and as the measures are very favourably situated for working and prospecting, a small amount of work should give much definite information. The measures appear to be quite regular and are easily accessible. There is a very good grade from the W. P. & Y. railway, into these claims, and considering their proximity to the Whitehorse copper deposits, the town of Whitehorse, and the Watson and Wheaton Rivers claims, this coal, which should make a good fuel, should prove of considerable value in the near future. No seams of coking coal were found.

Four samples of the coal were taken, and have been analysed by Dr. Hoffmann of this Department with the following results:

A is an average sample of the nine foot eight inch seam at the end of the sixty foot tunnel.

B is an average outcrop sample of the two foot six inch seam.

C is an average outcrop of the ten foot four inch seam.

D is an average sample of an outcrop found in the creek just below the tents that were occupied when the claims were worked. This may be the same seam as one of the others.

	A.	B.	C.	D.
Water	2·15	3·76	3·78	2·35
Volatile combustible matter	6·01	8·34	10·06	6·65
Fixed carbon	69·86	62·50	38·38	42·27
Ash	21·98	25·40	47·78	48·73
	100·00	100·00	100·00	100·00

A trip was made at the end of the season down the Lewes river in order to examine the coal measures in the vicinity of the Tantalus and Five Fingers mines and at Tantalus Butte.

Tantalus Mine

This mine is situated on the left limit of the Lewes river, about one hundred and ninety miles down the river from Whitehorse. The coal outcrops on the river banks, and is naturally well situated for economic working. The cars are hauled out of the tunnels by mules, and by cable up an incline, at the top of which the coal is dumped into bunkers ready for loading.

Most of the river steamers burn this coal, and about 7,000 tons will be loaded this season.

There are three seams opened up, only the lower two of which are being worked at present; others may be found, as the formation is, in most places, heavily covered. The coal is worked by the stall and pillar system from two tunnels, which, when visited in October, were in 692 and 708 feet respectively on the bottom and middle seams. From the bottom seam nine rooms had been or were being worked, and were up from 50 to 115 feet, No. 1 having been run up 160 feet to the surface for air. From the middle seam there were ten rooms up from 70 to 150 feet. Although the seams are dirty, the coal could easily be sorted; but as wages are $5.00 and board, for underground, and $4.00 and board, for surface work, no sorting has yet been attempted.

The following section was measured near the end of the tunnels:

Bottom seam	Coal	2 feet,	4 inches.
	Shale	0 "	7 "
	Coal	2 "	0 "
	Shale	0 "	8 "
	Coal	2 "	11 "
Middle seam	Shale	4 "	0 "
	Coal	2 "	3 "
	Shale	0 "	2 "
	Coal	0 "	7 "
	Shale	0 "	2 "
	Coal	2 "	0 "
	Shale	0 "	2 "
	Coal	1 "	8 "
	Shale	7 "	0 "
Top seam	Coal	3 "	0 "
	Shale		

The measures are quite regular and can be traced over twenty miles down the Nordenskiöld river to the south and for over ten miles to the north, from which it may be inferred what an enormous amount of coal this district contains. When the measures have been prospected they may be found to extend much farther. Only coal near the river is at present of economic value. The dips are to the east and vary in the tunnels from 24° to 40°. Three average samples, E, F, and G, were taken respectively from the breasts of the bottom and lower seams and from the top seam where cross-cut from the middle seam, probably about 300 feet in. These samples analysed by Dr. Hoffman gave:

	E.	F.	G.
Water	0·75	0·76	0·82
Volatile combustible matter	23·61	24·74	25·12
Fixed carbon	55·21	58·60	66·03
Ash	20·43	15·90	8·03
	100·00	100·00	100·00
Coke per cent	75·64	74·50	74·06

These results show that the coals in the laboratory make a good coke, and it is hoped that they can be used when the copper deposits of Whitehorse, and the minerals in the other parts of the Yukon, become further developed. It is also hoped that these coals may be found much nearer Whitehorse.

Tantalus Butte

At Tantalus Butte, across the river from the Tantalus mine, the same measures again outcrop, but dip to the west, showing the presence of an intervening synclinal fold. The coal outcrops are near the top of the Butte, about four hundred feet above the river, wash and terrace material covering the formation lower down. The best seam seen contained five feet of good, firm, clean-looking coal with one foot of coal and shale on the bottom. Other seams were dirty and narrow, but good ones may be here obscured by drift, etc., as practically no work has been done except small surface cuttings. Altogether, the general conditions of the measures, including dip, strike, etc., are similar to those at the Tantalus mine, and the property will probably be worked in the near future. The surface samples obtained did not give a firm coke, but possibly fresh coal would give a different result. The following is the result of an analysis, by Dr. Hoffmann, of an average outcrop sample from the best seam.

Water	9·48%
Volatile combustible matter	32·28%
Fixed carbon	53·51%
Ash	4·73%

Five Fingers Mine

This is situated on the east side of the river about ten miles north of the Tantalus mine. A considerable amount of coal has been shipped from here, but the old workings are closed now on account of being dangerously situated on the steep clay and sand bank of the river, subject to mud slides. The old slope was down about 350 feet with rooms run off it, the seam in the lower rooms being three and a half to four feet wide. The new slope now being sunk is to the north and in safe ground, and at the time visited was down about 525 feet, dipping to the east at 16°. This seam, which is not the same as that mined in the old workings, was at this depth about two feet wide, and was apparently becoming wider. It had previously narrowed to about six inches. An average sample of the two feet, analysed by Dr. Hoffmann, gave:

Water	4·26%
Volatile combustible matter	40·26%
Ash	10·81%
Fixed carbon	44·67%
Coke per cent	55·52%

The coke is a firm coherent coke.

These measures are not the same as those at the Tantalus mine which appear in the valley about three and a half miles to the east of the Five Fingers mine, and also up a small creek about three or four miles to the east from the Five Fingers rapid.

Geology

General

In studying this portion of the Yukon, as in portions of British Columbia to the south, a striking similarity in the geology is noticed in a north-west and south-east direction, all the main horizons extending parallel to the Pacific coast line.

The principal geological formations have been placed in the following divisions, beginning with the oldest:

Schists

Lying next the granites along the western edge of this district, in places, are some schists, chiefly chloritic, sericitic and hornblendic, and sericitic and schistose quartzites, which are probably the oldest rocks observed this season.

Lower Câche Creek Series

This series consists of cherty quartzites, slates, argillites, altered diabases and basic andesites, some serpentines, and some thin beds of limestone, and is probably Lower Carboniferous or Upper Devonian.

Limestone

Overlying the slates, cherts, etc., of the above class is a considerable thickness of limestones forming a range of hills along the eastern edge of this district. It is probably Carboniferous, and perhaps belongs to Dr. Dawson's Upper Câche Creek series.

Granite

Cutting the above formations are the granites of the Coast range, which are now generally considered to be Jurassic.

Windy Arm Series

This consists chiefly of fine-grained, greenish, freshlooking porphyrites, but includes some diorites, gabbros, andesites, basalts, tuffs, etc.

Tutshi Series

This name has been given by Mr. McConnell to a series of bedded rocks, chiefly tuffs, tufaceous sandstones, conglomerates, etc., which have been found to overlie the Windy Arm rocks conformably and, in fact, to pass gradually down into them. Both appear to belong to Dr. Dawson's Porphyrite series.

Granite Porphyry

Cutting all the above formations are some dikes and masses, generally quite small, of granite and syenite porphyry.

Scoria and Basalt

Overlying all are some recent lavas of Tertiary age.

Older Schistose Rocks

These rocks occupy altogether but a small area, chiefly in the form of a narrow disconnected belt, with occasional small outlying areas adjoining the granites. They can be traced almost continuously, with an average width of about one-half mile, from the West Arm of Lake Bennett, north to the Watson river. They vary greatly in appearance and mineralogical composition, and probably represent rocks of different origins and different ages. Their occurrence and general description corresponds somewhat closely with those found by Mr. J. C. Gwillim in the Atlin district, and placed in Division IX in his table of formations, and considered by him to be Lower Palæozoic. They also all probably belong to Mr. McConnell's 'Older Schistose rocks', including the Klondike series, Moosehide group, and Nasina series of the

Klondike gold fields. Mr. Brooks[1] considers the Nasina series to be Lower Palæozoic or Pre-Cambrian, and Mr. McConnell[2] considers a portion of the Klondike series, and probably the whole series, to be referable to the age of the Pelly gneisses[3], and to be probably nearly contemporaneous with the Moosehide group[4]. So the probability is that these rocks are all Pre-Ordovician.

Some fine-grained, light-coloured, fine schistose, chloritic and sericitic schists, which break up readily into very thin schists, and are generally somewhat glossy in appearance, are found along the eastern edge of Mt. Stevens, somewhat to the east of the main belt. These are evidently very old, and correspond lithologically to Mr. McConnell's Klondike schists found to the north, and described in his report on the Klondike gold fields. No other rocks at all closely resembling these were seen in the district. A number of quartz veins, frequently several feet in width, outcropping for several hundred feet, and often carrying copper minerals and occasionally galena, were noticed in these schists. The veins occur generally along the foliation planes of the schists, and seldom in true fissures.

On the hills just to the west of Mt. Stevens the schists are wider than elsewhere observed. Towards their western margin they are generally quite coarse, presenting the appearance of extremely crushed hornblende-granites, breaking readily along the planes of schistosity, and present a coarsely mottled appearance due to the occurrence of large altered feldspar crystals. These probably correspond to the Pelly gneisses. Farther east are some greenish, chloritic, as well as some fine grained and more quartzitic schists. These are all somewhat closely foliated, though they do not, as a rule, cleave along the planes of schistosity, but break into more block-like pieces; have not, to nearly the same extent, the glossy sericitic or chloritic appearance of the Mt. Stevens rocks, and are generally more compact. Quite a number of quartz veins, generally parallel to the schistosity, and often well mineralized with pyrite, copper minerals and galena, and carrying gold values, occur in these schists.

The schists, having a width of about a third of a mile, are again seen on Gold hill, where they are very similar to the eastern portion of the belt west of Mt. Stevens. From here they can be traced for some distance towards the Wheaton river to the south, through Mt. Hodnett, and towards the Watson river to the north. These are greenish, generally dark-coloured, fine-grained and closely foliated, but only occasionally cleave along their planes of schistosity. An examination of their sections and specimens of the Gold Hill schists shows them to be generally sericitic or schistose quartzites grading into silicified slates, or rocks originally containing much argillaceous material, but which have by shearing received their slaty or even schistose structure. The specimens examined are all decidedly of sedimentary origin and the banding, in some cases, appears to be due to bedding rather than to shearing. The rocks are, however, very much altered, and the original minerals are to a great extent replaced by secondary ones. These schists closely correspond lithologically with Mr. McConnell's

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[1] Twenty-first Annual Report of the United States Geological Survey, part II.

[2] Report on the Klondike Gold Fields, p. 17 B.

[3] Described by Mr. Brooks in the Twentieth Annual Report of the United States Geological Survey, part VII, pp. 460-463, and by Mr. R. G. McConnell in the *American Geologist*, Vol. XXX, July, 1902.

[4] Report on the Klondike Gold Fields, p. 23 B.

Nasina series in the Klondike district, and probably belong to it. Quartz veins several feet wide, and quite persistent, are found in these schists, and it is in one of these on Gold hill that the rich free gold quartz carrying the telluride minerals, hessite, sylvanite, and telluric ochre, was found this summer. Other veins also carry copper minerals, such as chalcopyrite, gray copper, malachite, melaconite, pyrite, galena, etc.

Very similar schists to those on Gold hill were found on Mt. Stony extending south to the north shore of West Arm, and north as shown on the accompanying map. No economic deposits were seen here.

As only a hurried examination was made of these rocks no more definite information concerning them could be obtained. All the schists above described have, therefore, been given the same geological colour on the map, and, though not necessarily of the same age, are probably for the most part detached portions of older schist series which have been included in the Coast granites, and are to some extent covered again by the more recent rocks.

Câche Creek Series

Limestone

Extending along the eastern edge of the district is a somewhat straight, prominent ridge of white limestone hills particularly noticeable on the eastern side of the mouth of Windy Arm. The limestone is usually fine-grained and is often in the state of marble. Some beds contain much quartz and often weather very rough; others are mainly composed of cherty matter. A similar limestone is shown on Mr. Gwillim's Atlin map, in the north-west corner, which practically joins the north-east corner of the district covered by this report. He considered this limestone to be probably of Carboniferous age, and Dr. Dawson states in the Report of Progress for 1887 that parts of the rock, thin sections of which he examined, proved to be largely composed of the remains of Fusulinæ, which are so typically Carboniferous and even Lower Carboniferous. He considered these beds to belong to his Upper Câche Creek series, described in his report on the Kamloops map-sheet and in other reports, and which is found in the interior of British Columbia practically from the north to the south, and to maintain many of its characteristics over the entire area.

A few small outcrops of the upper portions are seen projecting through the higher series of rocks to the west of the main range, especially just east of Mt. Needle, west of the railway; along the railway on the east side; just north of Lansdowne, and at the north-east corner of Mill Haven, at which last place, however, on account of the surrounding deep glacial wash, the contact with the other formations is not exposed.

No fossils of much importance were found in these limestones. The following imperfect specimens were obtained, and have been examined by Dr. J. F. Whiteaves, of this Department. He says:

"One fragment of a Cyathophylloid coral." This was found in the limestone range east of Whitehorse.

From the limestone hills about three miles west of De Witte were found: —"A few specimens of a small, smooth compressed Athyroid or Terebratuloid shell, which do not show the characters of the interior nor those of the beak and area of either valve." Also a "fragment of a bivalve shell with sculpture like that of *Rafinesquina alternata*." "These are Palæozoic or possibly Triassic."

Lower Series

Underlying the limestones is a series of cherty quartzites, cherts, slate, metamorphosed argillites and sandstones, serpentines, altered diabases and andesites, which, with the exception of the schists farther west, are the oldest rocks in the district and underlie particularly the eastern portions, being invaded by the granitic intrusions to the west. Lying, as these rocks do, under the limestones, they are naturally found along both sides of the range above referred to, where the erosion and folding have been sufficient to expose the rocks beneath it, the limestone appearing to lie in a shallow, almost flat, synclinal fold with the older rocks exposed on both sides. Mr. Gwillim found these rocks in the Atlin district, where they outcrop in a similar manner to those seen along both shores of Windy Arm and elsewhere to the east.

The rocks here placed in the Lower Câche Creek series closely correspond lithologically with those of this series described by Dr. Dawson,* and underlie the Fusulina limestones above mentioned.

They also correspond with Division VIII on Mr. Gwillim's Atlin map which includes "cherty quartzites, black slates, biotite slates, and limestones." The cherty quartzites, slates, and cherts are the most characteristic rocks of this series and the ones most easily identified. The altered igneous rocks are, especially where the outcrops are few and small, somewhat difficult to distinguish from the also somewhat altered igneous rocks of the Windy Arm series, which overlies the limestone.

The best exposures observed of these old sediments outcrop on Copper gulch (on the east side of Windy Arm), and about a mile and a half up a gulch on the west side of Windy Arm about two miles below Conrad. These outcrops are very similar except that the exposures on the west side of the Arm consist mostly of cherts and the cherty quartzites, whereas up Copper gulch quite a variety of rocks are seen, from finely bedded, and often highly folded and twisted slates, to very fine-grained, black compact altered argillites, and to the cherts and cherty quartzites which vary in colour from gray to black and in structure from finely bedded to massive.

The cherty quartzites are very noticeable and somewhat peculiar in character. They generally occur in well defined beds only a few inches thick, are always fine-grained, resembling chert, and are usually gray or light-coloured except where iron stained, when they very often present a red appearance on their weathered surfaces. They occasionally become nearly black, and at times are greenish or nearly white in colour. The argillites are fine-grained and generally black, ranging, however, from dark gray to black. They are often massive, but at times are somewhat slaty, finely bedded and quite siliceous, having a tendency to pass into cherty quartzites.

The slates are generally finely bedded and possess the typical slaty structure, cleaving quite readily along the foliation planes, and are occasionally very much folded and disturbed. They are in places more massive, however, and become very siliceous and grade into quartzites that vary from fine-bedded to massive.

Owing to these exposures being greatly disturbed, and of a very imperfect nature, no idea could be obtained—without much detailed work—as to the relative ages of the various members of the series. A somewhat con-

* Report on Explorations in British Columbia; Report of Progress 1876-77, and Pt. B, Vol. VII Annual Report.

tinuous but narrow outcrop of these slates and cherts is to be seen along the west side of Windy Arm for about two miles south from the limestone exposure at its mouth. Also, west of this, and connecting with the outcrops just above the Indian village across from Caribou Crossing, the same slates prevail and are often quite quartzitic. Up a small creek that heads just east of Mt. Escarpment signal, and runs into Windy Arm about two miles above the mouth of the Arm, the typically red, iron-stained cherts and cherty quartzites outcrop in the canyon in which the creek runs. Some outcrops of slate were also noticed in the south bank of the creek and above the cherts, while up from the mouth of a small creek running into the lower end of Nares lake, from the north, are typical slates and quartzites. Small exposures of these rocks were noticed immediately south of the limestone, half a mile east of Windy Arm, and another exposure about half a mile wide, of dark finely bedded slaty rocks, often possessing quite a schistose structure, occurs about a mile above Conrad.

A series of metamorphosed sandstones, alternating with beds of limestone, outcrops along the north side of McDonald creek on the east side of Lake Bennett. This outcrop is approximately one mile wide along the lake shore, and extends nearly to the head of the creek. This series consists of highly metamorphosed, well-bedded, generally fine-grained, hard, dark gray to reddish brown sandstones, which are somewhat calcareous throughout and decompose readily. They alternate with beds of limestone from fifty to one hundred feet in thickness, which are generally well-bedded, but are sometimes more massive. Numerous granite dikes one to four feet in width cut these beds in all directions. The series differs from any other seen during the season, but lithologically resembles part of the Câche Creek series. It is calcareous, contains limestone bands and is older than the granite; it has, therefore, been assigned to the Lower Câche Creek series.

Apparently associated with the slate and slaty rocks along Windy Arm are some schistose rocks, altered diabases, basic andesites, and serpentines, which are older than the granites and which are also here included in this Lower Câche Creek series. These rocks in places closely resemble the somewhat altered porphyrites and tuffs of the Windy Arm series, and, where the outcrops are small and the characteristic appearance of the rocks in the field is not pronounced, it is difficult to distinguish them. In fact, as the work done this season was necessarily of a somewhat preliminary nature on account of the large area covered, it is quite possible that some of the region mapped as the Windy Arm series properly belongs to this Lower Câche Creek series, or that the latter should be subdivided. The altered igneous rocks included in this series are, in most cases at least, somewhat newer than the cherts and slates, but more detailed work is needed to accurately map them separately.

The fact that coarse syenitic and granitic dikes invariably cut these igneous rocks, and do not cut the Windy Arm rocks, is a helpful feature in distinguishing them, as is also the fact that the Câche Creek igneous rocks are much altered.

On the east side of Sugar Loaf hill some splendid specimens are found of old, very basic eruptives which are in places almost entirely altered to serpentine. Another small area of similar basic rocks, although not so extensively altered, occurs on a small rounded hill about two miles to the south of Mt. Escarpment signal, and another at about the head of the south branch of Copper gulch, one mile south-west of this summit. In these two localities the rocks present a very rough, red, iron-stained appearance. On the east side of Windy Arm, and south of Rams Horn creek, is a ridge rising with a continuous high rugged escarpment facing the Arm, which, practically as far as the British Columbia and Yukon boundary, is composed chiefly of rather fine-grained, greenish, chloritic, schistose rocks which have been much altered, and are traversed everywhere, and in all directions, by a network of fine quartz veinlets, and which are also frequently cut by granitic dikes from one to six inches wide. These same rocks outcrop on the west side of Windy Arm north of Pooly canyon, as shown on the map; also at Conrad and to the north for some distance, and on the eastern side of the Arm below Conrad, extending to near the limestone. Here they are, as in some other places, heavily impregnated with pyrite. In all cases these rocks present the same general altered appearance, the granite dikes are numerous, and the quartz veinlets are always present.

On the west side of Sugar Loaf hill, and next the granites are some very basic, dark, altered, schistose rocks in which actinolite has been extensively developed. To the east of this hill, and extending to the north and south ridge about three miles away, are some rocks which have been much altered and broken and which weather very roughly and are generally quite basic, and often are heavily iron-stained on weathered surfaces. Thin sections of these rocks show them to be much altered basic andesites grading, in some cases, towards basalts. Similar rocks also outcrop on some small hills about one and a half miles to the north of the summit of the Montana tramway, which is somewhat over half way between the lower and upper terminals, and also along the tramway below this point, and to the north. On the hills to the south of Mt. Nares station are similar outcrops.

From the above descriptions it will be seen that although the rocks of this Lower Câche Creek series cover only a very small portion of the area surveyed, they are of a somewhat varied character. In fact it is the intention to place all these older rocks (i.e., older than the Coast granites), except the schist series, in this Câche Creek series. Dr. Dawson has stated that the age of the Lower Câche Creek rocks may be older than Lower Carboniferous, and that the series may include portions of Devonian age. The rocks placed in this series this season are probably of the same age.

Granite

The Coast granites which were intruded originally as a great batholithic mass in Jurassic times, and which extend along the western edge of this district, are mostly fresh and unaltered in appearance, and are often granite and granitoid rocks, generally gray in colour, and rich in hornblende, and are, for the most part, considered to be grano-diorites. They are as a rule coarse-grained and towards the edges of the intrusive mass, often become porphyritic and, from the abundance of pink orthoclase, in places, assume a pinkish appearance.

Along the west side of Mill Haven, and extending some distance to the north and west, is a much crushed and altered belt of these granites from which a section was examined microscopically by Dr. G. A. Young of this Department, who says:-- "Grano-diorite, composed essentially of quartz and plagioclase feldspar. The rock has been subjected to pressure which has fractured and deformed the quartz; in some cases the individuals have yielded entirely to the pressure and involved the feldspars in their ruin." These rocks outcrop along the western side of the Wheaton River valley.

A few small hills of the granite occur in this belt, as would be expected, but for some reason have escaped this crushing action.

The granites that outcrop along Lake Bennett near Caribou Crossing, and cut the Mt. Gray ridge, are generally coarse-grained and hornblendic, containing, at times, black mica, and are in all probability of the same age as the granites to the west. Wherever these granites could be found in contact with the porphyrites of the Windy Arm series, dikes of the porphyrites were seen cutting the granites.

Windy Arm Series

Newer than these Coast granites is a series chiefly consisting of porphyrites, diabases, andesites, tuffs, and basalts which cut through and overlie them, by far the greater part of the rocks being porphyrites which are generally fine-grained and greenish in colour and present a fresh, unaltered appearance. So predominant is this porphyrite that it might be considered a porphyrite series, but as the ores of the Windy Arm district occur in it, the writer has called it the Windy Arm series. Thin sections of specimens of these porphyrites from various parts of the district possess a strong similarity, and consist chiefly of phenocrysts of plagioclase which at times consist of interlocking individuals either somewhat broad or of lath-like habit, or of minute laths, or the plagioclase individuals may be more tabular in outline. Sometimes augite is abundant in the ground mass, and in a few places specimens were found containing augite phenocrysts. Pyrite is often found and in places hematite and magnetite are present in considerable quantities. When the rocks have been much altered, secondary minerals, as chlorite, are abundant. In places these porphyrites grade into diabases, andesites, etc., and true diorites and even gabbros have been found, but these are quite exceptional, and are probably due to cooling under different conditions. Tuffs and ash rocks are very plentiful in this series and vary considerably in appearance and composition. The porphyrites apparently grade into basalts with the typical prismatic jointing and also into the tuffs and ash rocks, and these into true sediments. The porphyrites have broken through their overlying beds and have flowed through and over them mostly in the form, apparently, of great laccoliths, sheets, etc., the flow structure being frequently well marked. Where the porphyrites come in contact with the coast granites, dikes of them fill the latter, and there are numerous cases where the porphyrites fill inequalities in the surface of the granites. Violent explosions accompanied the eruption or eruptions, causing the formation of tuffs, which are often very coarse. These are very characteristic, and are met frequently over the entire district. Often they present on weathered surfaces the appearance of conglomerates due to particles, lumps, etc., either quite fine or several inches in diameter, of one porphyry or porphyrite in a ground mass of a somewhat different looking porphyry or porphyrite. There have been great showers of ashes and finer material which have consolidated into generally fine-grained, greenish rocks showing bedding structure which is often quite pronounced, giving the rocks the appearance of fine-grained sandstones and shales. In places these particles have fallen into water, and show to some extent water sorting action, and are mixed with argillaceous and other sedimentary materials. These rocks seem to grade into true sediments as shales, conglomerates, bedded cherts, cherty quartzites, etc., which carry coal seams. It is somewhat difficult to draw any decided line between the true sediments and the bedded tuffs and ash rocks, which seem to lie conformably on one another. However, it has been decided to attempt this for economic reasons, and the true sediments with some of the upper bedded ash rocks and tuffs are included in the Tutshi series described below. The rest are included in the Windy Arm series. The whole series appears to correspond to Dr. Dawson's Porphyrite series found to be so extensive in British Columbia, and which he described somewhat in detail in the Report of Progress of this Department for 1876-77. This Windy Arm series also corresponds, in all probability, to the rocks of Division IV on Mr. Gwillim's Atlin map above referred to, and includes the corresponding representatives of the greenstones of his Gold Series Division VI, which are newer than the granites. The corresponding representatives of the other members of Division VI, which are older than the granites, have been included in this report, and on the map in the Lower Câche Creek series. In the writer's summary report on this district mention was made of some altered sediments newer than the limestones. These upon examination proved to be mostly tuffs, and have been also included in the Windy Arm series.

The whole series is somewhat calcareous, and the porphyrites generally contain enough lime—due chiefly to the alteration of the feldspars—to cause effervescence with acid. Bands of limestone, locally spoken of as limestone 'dikes', occur in a number of places, up to fifty feet in width. Probably the most noticeable instance, generally about fifteen feet wide, extends along the west side of the Mt. Gray ridge from the north end of the ridge to south of west of Mt. Pyramid station. On Mt. Needle it is seen about three-fourths of the way to the top where it dips into the hill at low angles and extends almost in a straight line to about three-fourths of a mile west of Mt. Pyramid station, where it outcrops along the top edge of the main part of the ridge and has been in places staked off as mineral claims. A somewhat similar occurrence, from five to fifty feet wide, has been described above as being on the east side of Mt. Gray, and running at about right angles to the shore of Lake Bennett, and along which the College Green and other claims have been staked, copper minerals having been deposited along the contact of lime and porphyry.

Typical porphyrites of this series outcrop around the Windy Arm mining properties, and practically the whole of Mt. Gray, Mt. Ptarmigan and Mt. Twin consist of these rocks. The coarse tuffs are well seen along the top of the Mt. Gray ridge, particularly the top of Mt. Needle and Mt. Gilliam. They are also seen around the station at Mt. Twin and just south of the Thistle mine up towards Mt. Matheson, and at other places.

Along the ridge from Dails peak towards Mt. Matheson, and along the high ridge south of the Big Thing group, are typical basalts.

The rocks along the western edge of Mt. Needle, which are chiefly ash rocks and tuffs, as seen in the distance, show distinct bedding, the beds being generally from one to four feet wide or even wider. On approaching them the bedding is not so evident and probably would not be recognized. This same feature was noticed in other places.

In the Windy Arm district, in particular, red belts or zones of rock from a few feet up to several hundred feet wide occasionally occur, and are often spoken of as porphyry dikes. These in most cases are only portions of the porphyrite that are particularly rich in iron, oxidation having given the red colour to the rock which, if broken, will be found to be red only on the weathered surfaces and as far as the weathering extends. At one place, however, on the west side of Lake Bennett, below the mouth of the Wheaton river, a belt of these porphyrites contains a considerable amount of hematite as well as pyrite and magnetite, and seems to be permeated throughout by the red colouring. On the east side of Lake Bennett is a somewhat sharp ridge of red iron-stained hills about two miles from the lake and extending south from McDonald creek three or four miles, the rocks of which upon being examined microscopically proved to be tufaceous sandstones which lie between porphyrites.

The rocks of the narrow belt extending along the eastern face of Mt. Stony, and lying between the schists on the west and the badly sheared granites on the east, are generally fine-grained and greenish in appearance, and in places have an apparent schistose structure. Under the microscope they prove to be highly altered basic volcanics almost entirely changed to zoisite, epidote and actinolite. These have therefore been included in the Windy Arm series,—the same force which has so broken and crushed the granites to the east probably having also altered these.

The whole of Mt. Lakeview is composed of light-coloured rocks showing apparent bedding in places, but a number of thin sections were examined which, under the microscope, proved to be typical porphyrites very similar to the others of the Windy Arm series. Along the foot of the mountain, however, and just north of the signal, some exposures of dark, finely bedded tuffs were seen.

Tutshi Series

This name was given by Mr. McConnell to include the "Argillites, tufaceous sandstones, conglomerates, etc.," of the Windy Arm district, and the writer has adopted the name for all rocks in the area that appear to belong to this same series. These Tutshi rocks, which in all probability, as mentioned above, correspond to the rocks of Mr. Gwillim's Division III on his Atlin map, belong, as well as the Windy Arm series, to Dr. Dawson's Porphyrite series and correspond lithologically and stratigraphically with his Jackass Mountain series (Report of Progress for 1871-72), which he has decided overlie conformably the rocks described in the report of 1875 as belonging to the Porphyrite series. This latter consists chiefly of igneous products, and the Jackass Mountain series resembles rocks of ordinary aqueous origin; but as rocks which were originally flows are very difficult to distinguish from those of the same chemical composition, though of fragmental origin, as ashes, sands, etc., they have all been placed under the same name, and in his report of 1876-77 all are included in the Porphyrite series. As this Porphyrite series covers such a large portion of the district, and as coal occurs in some of the beds, it has now been decided to distinguish them on the map as far as possible, although it is to be understood that no sharp lines are drawn between them. All rocks, therefore, which are of aqueous origin, and all those associated and interbedded with them, are placed in this Tutshi series, as water action has had more or less effect on all of them and has not affected the rocks of the Windy Arm series. Dr. Dawson considered the Porphyrite series to be probably a link between the Jurassic and Cretaceous, making the Jackass Mountain beds Lower Cretaceous. The fossils found this season in these Tutshi beds, being all typically Lower Cretaceous, further bear out this correlation.

In the vicinity of the Union mines, and on the eastern slope of Mt. Follé, are some fine-grained, very hard, brittle, often cherty, well and often thinly bedded rocks, generally red with iron stain. They break up into sharp angular pieces and prove, when examined petrographically, to be for the most part cherty quartzites, and banded cherts, containing much pyrite, and the base chiefly a chemical precipitate. Numerous specimens of a type of fossil were found and have been examined by Dr. Whiteaves of this Department, who says:—"*Prioncyclus woolgari* (Mantell)—Several crushed specimens of an Ammonite that are possibly very young individuals of this species. In the Upper Missouri country, and elsewhere in the United States, *P. woolgari* is regarded as a characteristic fossil of the Fort Benton group. In Canada a few good specimens of it were collected by Mr. McConnell in 1880, in the lower 200 feet of the La Biche shales, at two localities on the Athabaska." This band of reddish weathering rocks is seen outcropping for some distance in a north-westerly direction, passing just to the east of Mt. Perkins signal and forming the central part of Red ridge for some distance on both sides of the signal, where there are porphyrites, tuffs, etc., of the Windy Arm series.

Just to the west of this belt, and outcropping on the ridge running west from the Union Mines and about midway to Pugh peak, are some shales, conglomerates, cherts, and cherty quartzites, carrying some coal seams. These rocks are of the same horizon as the coal measures which have been opened up about seventeen miles in a south-westerly direction from Whitehorse. The chief horizon marker consists of a number of heavy beds of a peculiar looking conglomerate, made up almost entirely of hard, well-rounded, generally small pebbles of slates, cherts, quartzites, etc., in a siliceous matrix,—giving the rock a very cherty, hard appearance. Some black shales both finely and coarsely bedded were found next the coal seams. Also, adjoining them and the conglomerates are a number of beds of hard, fine-grained, often brightly coloured bedded cherts which are banded, the bands being generally narrow, about a quarter of an inch or less, and prettily coloured, the colours varying from grays to reds and blacks. There are, too, some light coloured, thinly bedded, and also some more coarsely bedded shales and light coloured sandstones. The rocks here are very much folded and distorted, and no attempt to measure a section was made. Three or four coal seams, apparently only a few inches in width, were seen, but their actual thickness was not determined. The area of these measures here is somewhat small.

Just west of the granite on Mosquito hill, and extending to the west of the two shown on the top of the ridge, appear the red, iron-stained, fine-grained, hard, brittle, cherty quartzites, etc., as seen on Mt. Follé. West to the main part of Mt. Goat, outcrops are very scarce, but those seen are tufaceous sandstones, tuffs and porphyrites. The main part of the mountain, however, consists of bedded rocks, as tufaceous sandstones, tuffs, cherts, etc., similar to those just west of Mt. Mosquito, and some coarse irregular conglomerates differing considerably from the conglomerates of the coal measures, in not having the cherty, slaty pebbles and being much less uniform in composition. There are here some finely bedded gray and greenish, and some almost black fine-grained tuffs and ash rocks, looking like shales, and some coarser ones that on account of being bedded might be mistaken for sandstones. Some fossils from this mountain have been examined by Dr. Whiteaves who says:—

"*Trigonia*, small, arcuate, and beaked species. Two other *Pelecypoda*, imperfect and undetermined. Shales with numerous valves of an *Estheria* or of very young specimens of *Inoceramus*. Also two crushed fragments of a small Ammonite, apparently referable to *Prionocyclus woolgari.*" These are all placed under the head 'Cretaceous' and are probably lower Cretaceous as described above.

A low ridge, the Watson ridge, running just west of the Watson river, seems to have been caused by a heavy bed or beds of conglomerate which, being harder and more difficult to weather than the surrounding rocks, have been left above the level of the wide valley in which they are situated. The conglomerates appear to be the same as those on Mt. Goat, Mt. Caribou, and Mt. Granger, being light coloured, and consisting of generally well-rounded pebbles of granite, porphyry, porphyrite, etc., varying in size from small up to four or five inches in diameter. In addition to these conglomerates—which do not resemble the conglomerate found in the coal measures, the ridge consists chiefly of fine-grained, well-bedded, dark, cherty, shale-like rocks and quartzites, and some lighter coloured, coarser bedded tuffs. Just across the railway from here is a parallel, but lower and less prominent, ridge of similar conglomerates which extends along the western side of Mt. Caribou, and has in places a reddish appearance due to iron-stain.

The western side of Mt. Caribou consists of conglomerates, similar to those on the ridge across the railway, the so-called argillites, tuffs, etc., all having a general strike of about true N. 13° E. Overlying the conglomerates are some thinly bedded, dark, somewhat soft, argillite-looking rocks composed chiefly of volcanic material. Overlying these again are some more coarsely bedded, fine-grained, almost black, very hard, slate-like rocks which prove, however, when examined under the microscope, to be tuffs. Besides these are some lighter coloured tuffs generally fairly well-bedded, and varying in texture from fine-grained to about that of an average sandstone. These bedded fragmental rocks, which are mostly pyroclastics, extend along the ridge to the north of Mt. Caribou and south of the signal for some distance, but as the deep draw is approached dividing this mountain from Mt. Nares the rocks become nearly all grayish and greenish porphyritic looking tuffs and tufaceous sandstones, and grade into true porphyrites. It is, therefore, difficult to draw a line here between this and the Windy Arm series.

The top of Mt. Wounded Bull, to the north of here and east of Robinson, is chiefly composed of the red weathering, fine-grained, hard, cherty quartzites, banded cherts, etc.

The southern part of Mt. Golden Horn, and the low ridge of hills to the south-east of it running north from Mt. Mosquito, are also composed almost entirely of the reddish, weathering hard rocks almost identical in appearance with those at Red Ridge signal, and in the vicinity of the Union mines and elsewhere. Thin sections of these rocks examined microscopically prove them to be the same, and to be bedded and banded cherts and cherty quartzites containing pyrite, the base being chiefly a chemical precipitate.

The wide valley in which the railway runs west of Caribou and Mt. Wounded Bull, and which, particularly in the vicinity of Lewes lake, is floored with heavy silt deposits, is probably underlaid by these Tutshi rocks. They outcrop along both sides of the valley, there is coarse float in a number of places, and one outcrop was found along the railway about two miles south of Robinson.

The outcrops seen on Mt. Double from the east side of Coal lake on the west, and including the long ridge extending from it in an easterly direction, are chiefly light coloured, fairly well-bedded, generally coarse-grained tufaceous sandstones and massive beds of conglomerates, the latter being generally quite coarse and composed of well-rounded, very irregularly sized pebbles and boulders up to five or six inches in diameter, of granites, porphyrites, and the general types of the other rocks of the district, which are often only very loosely cemented together. Outcrops, except on the summits of the mountains and ridges, are very scarce and it would seem that these sandstones and conglomerates, which weather less readily than some of the finer-grained and softer, more shaly rocks with which these are associated in other places are accountable for the summits and ridges, and that the lower portions of the hills, which have weathered to a greater extent, are composed of these softer rocks. Dips and strikes are very irregular and of little value here. These sandstones and conglomerates are very similar to those seen on Mt. Caribou, Mt. Granger, and elsewhere. Just west of the Mt. Double signal are also some of the harder, reddish-weathering cherty quartzites, as seen to the south-east of Golden Horn, on Red ridge, and elsewhere as mentioned above.

Coal ridge, which extends along the western side of Coal lake and just across from Mt. Double, is also composed of rocks resembling those to the east of it, the conglomerate being very noticeable, and also the red, cherty beds which form the northern end of the main part of the ridge.

On Mt. Granger, farther to the west, the same beds continue as were seen on Coal ridge and Mt. Double, these being all in the general line of strike. Commencing a short distance to the south of the summit of this mountain, and extending over the northern edge to the granite contact, are the red, hard, fine-grained, cherty quartzitic rocks described above. The strikes here as elsewhere are very irregular. One near the granite contact was true N. 28° E. with a dip of 70° to the north-west. The general strike is here more nearly east and west. Underlying these beds is a great thickness of hard, coarse, light-coloured sandstones and conglomerates similar to those on Mt. Double, with a few intercalated, finer, darker, and softer beds, most of them probably pyroclastics. These extend to nearly the foot of the mountain, i.e., on its south side, the conglomerate beds being of great thickness, in some instances several hundred feet, and apparently overlying the coal measures which outcrop in the valley to the south of Mt. Granger. This was the only place seen this season where anything approaching a complete section of this Tutshi series could be measured, and even here it would be somewhat difficult to arrive at anything like accurate results, the coal measures being to a great extent covered with glacial wash material, and the higher rocks being considerably disturbed. Moreover it was very late in the season when this district was examined, and recent heavy falls of snow, covering considerable portions of the formation, made these somewhat rugged hills dangerous to traverse. However, this series here has a considerable thickness, probably between three and four thousand feet at least.

As mentioned above, only a partial section of the measures was seen, as they outcrop along the valley having approximately the same general strike, and are mostly heavily covered with drift. Descriptions of the coal are given in the economic portion of this report. The general strike of the measures is about true N. 74° W. At the tunnel the strike is true N. 63° W. with a 42° dip to the north-east. The most noticeable beds in these measures are the conglomerates which are similar to those seen between the Union mines and Gold hill, and are readily distinguishable from other conglomerates in this district. They are generally much finer and of more even size, and all the beds not only present a very similar appearance but are quite uniform throughout. They are composed of pebbles of cherts, slates, and quartzites, and are generally somewhat dark in colour and very hard, and usually cherty in appearance, the pebbles being well cemented together with a siliceous material. There are at least six of these beds here, generally from seventy-five to one hundred feet in thickness, but some narrow beds of only a few feet were observed. These cherty conglomerates have evidently been derived from the cherts and slates of the Lower Câche Creek series, and are probably the lowest true sediments above them in this district. The rest of the measures consist mostly of somewhat coarse, light-coloured sandstones, some beds of finer and darker shales being also seen. The conglomerates, sandstones, etc., of Mt. Double extend to the south to a point about midway between the station and the north branch of the Watson river, as shown on the map, where the Windy Arm rocks commence. Near the contact the coal measures from the south of Mt. Granger strike across this ridge, and were traced to the deep valley separating it from Mt. Lakeview.

In the Windy Arm district, to the south and on the north-east side, particularly, of Mt. Brute, are some peculiar fragmental rocks. These, very irregular in texture, are composed chiefly of volcanic ashes, lapilli, and quite coarse materials that have fallen into the sea and have been cemented together, often by clays. These rocks, not noticeably bedded and showing very little sorting action, have the general appearance of conglomerates. To the south, and running in a southerly direction to the head of McDonald creek, keeping to the west of it, is a rather narrow exposure of the reddish weathering cherty quartzites, etc.

There is also the belt of these Tutshi rocks noted by Mr. McConnell in the southern portion of the Windy Arm district. Outcropping along the shore of the Arm above Whynton, B.C., and extending in a north-westerly direction to the north of Mt. Dundalk, keeping south of Knob hill, they consist chiefly of conglomerates, tufaceous sandstones, tuffs, etc. The conglomerates are somewhat coarse and similar to those described above as occurring on Mt. Granger, etc. The sandstones are generally light-coloured, hard somewhat coarse, massive, and usually in very thick beds. There are also some much finer, darker coloured thinly bedded tuffs, which are particularly noticeable for some distance along Windy Arm, where they appear as fine-grained, dark argillites. All these rocks appear to be pyroclastics, and thin sections of the so-called argillites, examined under the microscope, are seen to be tuffs. The only fossils found here are imprints of some valves of young specimens of a species of *Inoceramus* which were examined by Dr. Whiteaves, and which he considers the same as the species found on Mt. Goat, and probably Lower Cretaceous.

These Tutshi rocks are frequently cut by porphyry dikes, generally fine-grained and greenish in colour; in a few places light-coloured pink porphyry dikes were observed to cut both the Windy Arm and Tutshi rocks. These dikes, which probably belong to some period of volcanic activity in Tertiary times, are in all cases too narrow to be shown on the accompanying map.

From the coal seams at the Tantalus mine, which are of the same horizon as those south-west of Whitehorse, and to the east of Pugh peak, as described above, some fossil plants have been examined by Dr. Penhallow, who says:—"All the material appears to be the same as the specimen of

Thyrsopteris elliptica, Fontaine, as figured by Ward in the 'Status of the Mesozoic Floras of the United States', vol. XLVIII, pl. LXXI, figs. 12 and 13; and to this the present specimens are provisionally referred. It is to be observed, however, that there seems to be some question as to the correctness of Ward's reference, since the specimen cited is quite distinct from the original type of *Thyrsopteris elliptica* as described by Fontaine (in 'Potomac Flora, vol. XV, p. 133, pl. XXIV, figs. 3, 3a.'), and it is quite possible that further and more complete specimens may show this to be an entirely new species. A somewhat related flora was described by me in 1898 as obtained by Mr. J. B. Tyrrell from the Nordenskiöld river. All the specimens shown, however, were specimens of *Cladopliebis*, and they indicated Cretaceous age. "The specimens from the Tantalus mine present a flora with the same facies as those from the Nordenskiöld river, and the whole conform to the flora of Kootanie age. (Lower Cretaceous,—sometimes assigned to the Jurasso-Cretaceous period, near the close of the Jurassic and at the beginning of the Cretaceous.)"

This further evidence bears on the correlation of the Tutshi series as made above.

Granite Porphyry

In a number of places intrusive dikes, and masses of granite and syenite porphyry were seen cutting all the other rocks except the Tertiary basalts, etc. The areas of these are as a rule too small to show on the accompanying map, being generally dikes less than five hundred feet wide, but occasionally wider.

One of the most noticeable was a typical syenite porphyry, cutting Red ridge about one-half mile west of the signal, and continuing through Mt. Perkin to the eastern edge of Pugh peak, about one-half mile from the summit, being from nearly a half mile wide on Red ridge to about eight hundred feet wide east of Pugh peak.

Just west of Mt. Double summit is a similar dike about two hundred feet wide. This, however, on account of scarcity of outcrops of any kind, could only be traced a short distance.

On the south-east portion of the ridge forming the eastern portion of Mt. Lakeview is an exposure of these syenite porphyries, cutting through the Windy Arm porphyrites, which are here somewhat lighter coloured than usual. Outcrops were also seen forming portions of the summits of Caribou and Minto mountains and elsewhere.

Scoria and Basalt

The newest rocks in this district are some recent dark basic lavas, which are of Tertiary age, and which are only seen in the northern portions. It is these lavas that have flowed across the valley of the Lewes river and caused the Whitehorse rapid and Miles canyon. Along the sides of the latter these basalts show particularly well the prismatic jointing peculiar to these rocks, causing them to appear as vertical pillars. These rocks also extend to the west some distance, and are seen occasionally to the west of the railway along Johnson creek. The western portion of Black ridge, to the west of the Golden Horn, is composed of these lavas.

Boulders of scoria, often several feet in diameter, are thickly strewn over the surface along the north and north-west sides of Mt. Double, and to the west of Golden Horn. These, like the lavas, in most places are quite vesicular, the cavities not as a rule being yet filled with secondary minerals.

These Tertiary lavas somewhat resemble those of the Windy Arm series, but the latter are more disturbed and have the cavities of their originally vesicular rocks almost invariably filled with secondary minerals, while those of the former are commonly open and are much fresher looking.

For the greater part of the work of microscopically examining the rocks mentioned in this report I am indebted to Dr. G. A. Young, of this Department and to Dr. R. A. Daly.

Superficial Deposits

Filling the wide valleys of this district are, in most places, considerable thicknesses of gravels, clays, silts, etc., which completely obscure the rock formations. All such valley deposits have been mapped under one geological colour.

They were not studied in detail, but the silts which fill a considerable portion of the wide valley bottoms, particularly of the valley in which the railway runs to the north of Caribou Crossing, and are often thick, were very noticeable. These silts are the overwash of the glacial epoch, and are now being trenched by the different rivers and streams. Particularly in the vicinity of Lewes lake, which was partially drained during the construction of the railway, these are well seen and are very typical. They were evidently deposited in sluggish water, and at a considerable distance from the source of the material. Nearer the edge of glaciation the materials are more heavily bedded, much coarser, are cross-bedded to a greater extent, and show every evidence of being fluvial deposits, and of having been deposited in swiftly running water.

A noticeable feature in this district is a widespread layer of volcanic ash or pumiceous sand, which forms a single layer and is evidently due to one period of eruption. It is much more recent than the silts and other glacial deposits, having been deposited in the river valleys, etc., after they had been cut down to about their present levels. In fact this ash is almost at the very surface, the grass roots being often in it. The layer is very even, except where it has been washed down from the hillsides into the valleys, and it evidently fell very gently, as snow might. It has an average thickness of from three to six inches, increasing to the north-west.

Map

In connexion with the map of this district, it should be said that, as the work was somewhat rapidly done, no attempt at elaborate detail has been made. To accurately differentiate and map the various formations would require a great amount of work. Towards the north, outcrops are very scarce, hence it was difficult to assign exact geological boundaries to the different formations. However, the map* probably indicates the different geological horizons accurately enough for the present needs of the district.

* The map is not included in this volume, but the area is in the Whitehorse map-area (Geol. Surv., Canada, Paper 44-14) and is presently being remapped. (H. S. B., 1956.)

1908

Introductory Notes

In his Summary Report for 1908, Mr. R. W. Brock, Director, gives the following résumé of the field work for that year in Yukon:

"Mr. D. D. Cairnes, assisted by Dr. O. Stutzer, was engaged in the Tantalus district near Whitehorse, defining the Coal area, with the object of determining the character of the coal and discovering the point nearest transportation where a commercial supply exists. Mr. Matheson had charge of the topographical work in connection with this investigation.

"Mr. Joseph Keele, who wintered on the divide at the head of the Pelly River, continued his exploration across the continental divide to the Gravel River, and descended this stream to the Mackenzie."

The information contained in Mr. Keele's preliminary account, published in the Summary Report for 1908, is all contained in his final report released in 1910 as a complete and separate volume. Only the final report is reprinted here.

PRELIMINARY REPORT ON A PORTION OF THE YUKON TERRITORY, WEST OF THE LEWES RIVER AND BETWEEN THE LATITUDES OF WHITEHORSE AND TANTALUS

by D. D. Cairnes

The work during the season of 1908 was virtually a continuation of that commenced last year, being chiefly devoted to the mapping, and geological examination of those areas north of Whitehorse and south of Tantalus, known to contain coal or to be underlain by coal-bearing formations; it being more particularly desired to ascertain the nearest points accessible to Whitehorse at which coking coal, similar to that at Tantalus, could be obtained. During the greater part of the season I was ably assisted in geology by Dr. O. Stutzer, lecturer in geology at the Royal School of Mines, Freiberg, Saxony; while Mr. H. Matheson performed in an efficient manner the greater part of the topographical portion of the work.

Men, horses, and supplies were obtained in Whitehorse, whence a start was made for Tantalus situated at a distance of 131 miles along the Whitehorse-Dawson road. The trip occupied twelve days, during which time certain reported coal discoveries along the route were investigated, and a rapid geological reconnaissance was carried on with the view of assisting in the determination of the best localities to map during the season.

Areas Mapped

Actual mapping was commenced at a point about 4 miles south of Tantalus, in order to extend to the south the Tantalus sheet which, begun during 1907, reaches from there to the north, and includes the district in the vicinity of the Tantalus and Five Finger coal mines. The territory examined and surveyed during the first part of the past season, extends from the limits of the older sheet, in a southerly direction for about 35 miles, with an average breadth of about 12 miles. It includes the first range of hills west of the Nordenskiöld river and the mountains on the east side of this stream as far as the easterly limits of the coal-bearing strata.

Between the southern bounds of the district thus examined and the northern edge of the Lake Laberge map, lying to the south, and surveyed during 1907, lies an unmapped area 14 or 15 miles wide. Since this strip of country was not known to be of economic interest, it was decided to omit it, and to devote the latter part of the season to the gathering of data for extending the Lake Laberge sheet to the south and west, so as to include certain known coal areas. This added portion is about 19 miles long by 14 miles wide, and extends along the wagon road from a point 2 or 3 miles above Braeburn to within about a mile of Kynocks.

In addition to the work in connexion with these coal areas, the writer made a rapid trip up the Hutchi river to Macks' Copper and to the Gilltana Lake claims. On the way south from Whitehorse, during the latter part of September, a day was spent at Conrad, investigating the latest developments on Windy Arm.

Physical Features

The entire district strictly belongs to the interior plateau region of the Yukon Territory, which, originally eroded to peneplain conditions, was subsequently subjected to a rather rapid uplift. Consequently the erosive agencies were greatly augmented, and the plateau thus formed was soon dissected, so that now it is only in places that distinct remnants of it are left, and these are not particularly evident within the area examined this season. The district consists, in a general way, of low, rounded hills, with only here and there a higher and more rugged peak or ridge relieving the otherwise monotonous landscape, though few rise more than 1,700 feet above the surrounding valleys.

The Nordenskiöld river and its three chief branches, the main waterways of the district, flow in wide, flat valleys, generally at least one mile, and often nearer two miles broad, forming the most pronounced topographical features of the country. One other important valley, though containing only a very small creek, apparently extends to the north end of Lake Laberge, and joins the Nordenskiöld valley about 6 miles above Montague. All the main valleys have beautifully terraced slopes rising from 5 or 10 feet to several hundred feet above the valley bottoms, possibly indicating successive uplifts of the district.

The effects of glacial action gradually decrease towards the north, and although glacial markings were seen within 5 miles of Tantalus, towards the northern end of the district, yet the chief results of glaciation have been to fill the valleys, cover the hillsides, and often the summits as well, with great thicknesses of gravels, clays, silts, etc. To such an extent is this the case that in many places there is almost an entire absence of rock outcrops, thus rendering the bedrock geology very obscure.

All the valleys of the district are dotted with irregularly shaped lakes ranging in size from mere ponds to others 6 or 7 miles in length. They often have no apparent inlets or outlets and seemingly originated during the final stages of the glacial epoch.

General Geology

What are believed to be the oldest rocks seen this season were discovered only in one place, where they consist of a group of chiefly fine grained, dark coloured amphibolite schists with light coloured, generally reddish gneisses.

They resemble members of the older schistose rocks and are considered to be of Pre-Ordovician age.[1]

In a gulch just north of Poplar mountain are some dark, generally thinly bedded, highly disturbed slates and cherts, resembling members of the Lower Câche Creek series of Carboniferous or possibly Devonian age.[2]

At numerous points in the southern portion of the district are outcrops of limestone similar to that seen in the southern portion of the Yukon, and there considered to be of Carboniferous or possibly Devono-Carboniferous age.[3] Fossils have been collected from these rocks, and it is hoped that when examined they will definitely decide the age of the beds.

Newer than the above limestones, but older than the Cretaceous, are some quartz porphyries which outcrop over considerable portions of the district. They generally are reddish blue to reddish gray in colour; and feldspars, biotite and quartz occur in well outlined, easily discernible crystals lying in a groundmass varying in grain from felsitic to quite coarse. A series of generally fine grained volcanics, chiefly tuffs, porphyrites, gabbros, etc., are also present in the district and belong to about the same period of igneous activity as the quartz porphyries.

Younger than all of the preceding groups is a series of Cretaceous age, consisting of a great thickness of sediments overlain by volcanics and bedded tuffs. Fossils were collected from this series, but as yet they have not been examined. In the Conrad district the representatives of these sedimentary and volcanic beds were placed in the Tutshi series.[4]

The basal member of the Cretaceous is a coarse, massive conglomerate having a total thickness of 500 to 800 feet, and in places, possibly more. The component pebbles and boulders are chiefly of granite, quartz porphyry, fine grained, green volcanics and limestone, those of granite predominating. This conglomerate is of frequent occurrence and is overlain by a thick group of conglomerates, sandstones, shales, etc., varying in thickness in different localities, from 1,000 to 3,000 feet or more.

The lower half of the column of Cretaceous sedimentary beds above the basal conglomerate is characterized by the presence of dark coloured, hard sandstones, with considerable thicknesses of dark to almost black, thinly bedded clay slates and shales. These are overlain by a group containing the lower coal horizon, and consisting chiefly of massive, coarse, friable sandstones, gradually becoming lighter coloured towards the top, where, in places, there is a thickness as great as 1,000 feet of almost perfectly white—except where iron stained—coarse sandstones composed of clear white, quartz pebbles cemented by a pure white, calcareous base.

The upper half of the group of Cretaceous sediments largely consists of massive beds of conglomerate, sometimes aggregating as much as 1,500 feet in thickness, and in this horizon occur the Tantalus coal seams. The pebbles of these conglomerates are altogether of chert, quartz or slate of the Lower Câche Creek series.

Overlying the above conglomerates is a group of fine-grained, bedded tuffs, often appearing as thinly bedded, dark to almost black, shales. These are intimately associated and interbedded with greenish tuffs showing no

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[1] Cairnes, D. D.—"Report on a portion of Conrad and Whitehorse Mining Districts, Yukon", pp. 24-25, Geological Survey, 1908.

[2] Op. cit., pp. 26-29.

[3] Op. cit., pp. 25-26.

[4] Op. cit., pp. 31-36.

bedding and appearing to pass into porphyrites, etc. In fact, in this district, the truly bedded deposits laid down under water, grade into and are so closely associated with the volcanics that it has been found impracticable to map them separately.

Newer than the above series of sediments and volcanics is a very extensive group of andesites, dacites, tuffs, etc., different members of which respectively cut or overlie the older formations. It is this volcanic group which is found overlying the conglomerate containing the coal horizon in so many places, and which renders the exploration of the coals very difficult.

Youngest of all is a volcanic group, in all probability of Tertiary age, consisting of scoria, basalt and basalt tuff, the tuff being the newest rock in the district. The basalts are either reddish or bluish in colour and are generally quite amygdaloidal. The tufaceous beds are often as much as 1,500 feet in thickness and are commonly quite coarse, containing bombs ranging from one to even two feet in diameter.

Economic Geology

Coal

There are two coal-bearing horizons of economic interest in this portion of the Yukon Territory. An upper horizon occurs near the top of the thick assemblage of conglomerate beds forming the upper half of the group of Cretaceous sediments, and to this higher zone belong the seams at the Tantalus mine and on Tantalus bluff. A second, lower coal-bearing horizon lies towards the base of the Cretaceous column as seen at the Five Fingers mine, also at a point west of the 69-mile post from Whitehorse on the Whitehorse-Dawson road and elsewhere.

The seams of the Tantalus bluff and the Tantalus mine doubtless extend a number of miles to the north and south of these places, but prospecting for coal is rendered particularly difficult there by the thick mantle of glacial and recent alluvial material which covers the greater part of the district. Beginning within a distance of two or three miles south of Tantalus, the Cretaceous sedimentary rocks are, for the greater part, covered with more recent Tertiary basalts, basalt tuffs, etc., so that although in the 20 miles immediately south of the Tantalus mine there is believed to be a great amount of coal, it will, in most places, require very careful prospecting to find it suitably located for mining purposes.

South of this district in which the strata have been so largely covered by later volcanics, the coal-bearing formations have been removed by erosion for a distance of over 30 miles to where a belt of the conglomerate of the upper coal horizon was found, traversing the district in a direction somewhat north of east. About 4 miles east of the wagon road the formation passes beneath a great thickness of volcanics, but to the north-west, the formation is believed to extend a number of miles, and may exist as a continuation of the outcrops seen crossing the Hutchi River valley about 30 miles from the mouth of the river. The formations near the road are in the form of a double synclinal fold, the upper portion of the formation, and consequently the upper coal horizon, being here eroded away. The seams of the lower horizon, however,were seen in several places, being particularly well exposed along a small creek about 4 miles west of the 69-mile post from Whitehorse. At this point a number of seams were uncovered and others probably exist, as very little prospecting has been done here. Of the seams seen, one was 7 feet wide, one about 4 feet wide, and several between 6 and 8 inches in width. The following are approximate analyses by fast coking of these coals, furnished by Mr. F. G. Wait, of the Mines Branch. No. 1 represents an average of an 18 in. seam, and No. 2 of a 7 ft. 6 in. seam:

	I.	II.
Water	8·98	12·02
Volatile combustible matter	29·62	34·28
Fixed carbon	48·30	42·56
Ash	13·10	11·14
	100·00	100·00
Coke, non-coherent	61·40	53·70
Ratio of volatile combustibles to fixed carbon	1:1·63	1:1·24

The ash in No. 1 is white; in No. 2, pale reddish brown.

Coal was seen also along the side hills to the east of the wagon road between the 117- and 118-mile posts, but the very thick covering of glacial material made the measuring of the seams very difficult. One seam, less than 2 feet wide, was seen on a small creek which crosses the road between the 113- and 114-mile posts. The following is an approximate analysis by fast coking of a sample from this seam by F. G. Wait, of the Mines Branch, who states that the coal "is probably a lignite which has been altered by intrusives."

Water	4·68
Volatile combustible matter	15·59
Fixed carbon	72·26
Ash, reddish brown	7·47
	100·00
Coke, non-coherent	79·73
Ratio of volatile combustibles to fixed carbon	1:4·64

All information that can be gathered concerning the Tantalus, Tantalus Butte and Five Fingers mines has already been published.* The areas described in this report, and two other areas previously mentioned**—one along the Lewes river between Hootalinqua and the Big Salmon river, and the second at a point a short distance from the Tantalus mine—include all the places north of Whitehorse and south of Tantalus at which the upper coal horizon is known to occur.

Mack's Copper

A few miles to the south-west of Montague, and only a short distance west of the western edge of the Tantalus map, are a number of mineral claims, locally known as Mack's Copper, because originally they were mostly owned by Mack brothers. The property is reached, usually, by a branch road leaving the Whitehorse-Dawson road about 6 miles above Montague, and following approximately the old Dalton trail south-westerly up the Hutchi river. From a point about 8 miles in on this road, a trail ascends the hills to the north of the claims which virtually are on the summits about 4 miles distant from and 1,900 feet above the valley. Practically all the ore in the vicinity appears to be on one claim.

* Op. cit.

** Cairnes, D.D.—"Report on portions of the Yukon Territory, chiefly between Whitehorse and Tantalus", Summary Report for 1907, Geological Survey Branch.

The ore, which occurs in a fine grained, greenish, porphyrite at or near its contact with limestone, consists chiefly of magnetite, with hematite in minor quantities, both being more or less impregnated with copper minerals, chiefly chalcopyrite, malachite and azurite. The main mass of mineral is in the form of a small knoll of almost solid iron ore, about 200 feet wide, by, perhaps, 300 or 400 feet long. On the south side of the hill the iron carries considerable copper, while the ore on the top of the knoll shows no copper, possibly because of leaching. A cross-cut tunnel has been started in one of the most promising places on the hillside, and when visited was in about 35 feet.

The only other work done on the property is in the form of an open-cut on an adjoining knoll to the west. The ore bodies in the two places apparently are not connected. The ore body in the more westerly locality is only 10 to 12 feet wide and lies next to and more or less in the limestone. The richest ore is found here, but has only been traced a short distance; it may, however, continue farther along the limestone, for the contact is so deeply covered with superficial deposits that only a few feet as yet have been uncovered.

The following samples were taken by the writer and have been assayed by Robert Smart, government assayer at Whitehorse. No. 1 is an average of the end of the tunnel, No. 2 is an average of the best 4 feet of the open-cut.

	I.	II.
Gold, ounces per ton	Trace	0·025
Silver, ounces per ton	Trace	3·400
Copper, percentage	1·80	5·55

The Gilltana Lake Claims

Most of these claims were staked during the season of 1907, though a number were located during the last summer. They are located on both sides of Gilltana lake, which lies some 15 miles in a north-westerly direction from Hutchi lake and village. Locally the claims are known both as the Gilltana Lake claims, and as the Hutchi copper.

The ore on the north-west side of the lake occurs at the contact between granite and limestone, and is in the form of narrow lenses of mineralized matter and quartz. The widest lens seen had a breadth of about 4 feet, but as a rule, the bodies are only from 1 foot to 2 feet wide and have at present no economic value.

Across the lake the claims are chiefly located over the face of a hill rising about 1,200 feet above the water. The country rock is mainly mica schists, interbanded with which are some beds of quartzite and limestone, the latter generally being narrow—3 to 4 feet wide, but sometimes as much as 50 feet thick. The strata strike about parallel with the lake and dip into the hill, so that the different bands of schist extend along the face of the hill, one above the other, maintaining an almost horizontal outcrop. In places these bands have become mineralized with magnetite, generally carrying copper minerals, chiefly chalcopyrite and malachite, and these constitute the ores bodies. The original schists show all degrees of mineralization and replacement, from portions entirely non-metalliferous to others now consisting of almost solid iron ore.

The best of these mineralized bands or zones average from 6 to 10 feet in width, although one was seen having a breadth of 20 feet and consisting of almost solid ore. The mineralized bands generally can be traced for 50 to 100 or even 200 feet, when the iron and copper minerals gradually disappear, or at times seem to be continued along other parallel bands. Three prominent, with other less important bands, were observed at different elevations on the face of the hill.

At the surface the copper minerals appear to have been leached out, but may be found re-deposited lower down. On the Helen claim, up Franklin creek, some open-cut work has been done, and there, in places, streaks of copper ore 1 foot to 3 feet thick were seen, included in wider bands that are much richer than observed elsewhere.

Apparently the ores are connected in origin with the intrusive granites found in the vicinity. The strata have been cut by dikes of light coloured hornblende andesites and dark fine-grained basalts, but these have had no visible effects on the ore deposits. The district is well worth prospecting and a number of the claims look very promising.

The following represent the results of assays of two samples from this district. No. 1 is a sample taken across the strike of one of the best looking bands which had a width of about 6 feet. No. 2 is a sample of one of the 3 foot streaks of copper ore on the Helen claim.

Gold, ounces per ton	Trace	Trace
Silver, ounces per ton	Trace	Trace
Copper, percentage	1·35	9·00

Windy Arm

Since the season of 1905 the Venus has been worked continuously with very satisfactory results, so that now a large amount of ore has been blocked out and some small, though high-grade shipments have been made to outside points. During the past year this is the only property in the district upon which work of any considerable importance has been performed; the reason for this inactivity being chiefly difficulties in company organization, etc., rather than the lack of promising conditions on the claims themselves.

The first concentrating mill built in the Yukon has, this season, been completed. It is situated on Windy Arm just below the Venus, the ore being carried from the workings to the mill by an aerial tramway. A 100 h.p. boiler, and a 75 h.p. engine, at present generate the motive power, but a water-power plant is being installed. The ore is first hand-sorted, then passed over a grizzly and the overs crushed by a Blake crusher. The ore is sized by trommels giving three products. Fine crushing is performed by a set of high-speed rolls and a Huntington mill. A set of jigs and four Callow screens concentrate the crushed and sized materials. The slimes are settled in six Callow settling tanks, and afterwards concentrated on three Wilfley tables and two Frue vanners.

The mill appears to have been well designated and constructed, and it is hoped that its erection will mark the introduction of the properties of the Conrad district into the class of producing mines.

Flora and Fauna

The principal varieties of trees in the district are white spruce, black pine, balsam poplar, aspen and willows. The white spruce is, by far, the commonest of these, covering perhaps half of the hillsides. Only in a few places were patches and isolated specimens of black pine noted, these being chiefly along the valley bottoms. Balsam, poplar, aspen and willow occur very plentifully in the valleys and on many hillsides, giving place very often to thick, dense growths of dwarf birch towards the summit.

Crowberries were very plentiful on all the hillsides. Black and red currants, blueberries, high bush cranberries and strawberries also occur.

Moose and bear are rather common in many places, caribou being less often seen. Fresh beaver cuttings were noticed in several places. Lynx and porcupine are very plentiful; while foxes, wolverines, wolves, and coyotes are in somewhat smaller numbers.

The lakes and streams are generally well filled with fish, chiefly grayling and pike. Salmon also come up the streams in great numbers in the autumn months.

The wide and extensive valleys of the Nordenskiöld and its branches are often covered with very luxuriant growths of certain wild grasses and timothy. Oats accidentally scattered along the roads, are seen to grow well. Many varieties of vegetables grown in Dawson, Whitehorse and intermediate points, compare very favourably with those imported. It is well known that horses generally winter safely in the valleys without being fed. A collection of the common plants of the district has been made by the writer, and these have been examined by Mr. John Macoun, of the Geological Survey, who considers them as proving the district suitable for agriculture, since the specimens are similar to those found in the Canadian Northwest and more particularly in the vicinity of Prince Albert and Edmonton. For these and other reasons it is hoped that it will not be many years before this district proves itself to be an important one for stock raising and agricultural purposes.

RECONNAISSANCE ACROSS THE MACKENZIE MOUNTAINS ON THE PELLY, ROSS AND GRAVEL* RIVERS†

by Joseph Keele

The present report is based on the results of investigations made during a portion of the years 1907-8, in the mountain region lying between the Pelly and Mackenzie rivers.

Since 1897—the year following the discovery of gold in the Klondike—field work has been carried on in the Yukon territory by various members of the Geological Survey. This work has, hitherto, been confined principally to the areas where active mining was in operation, and these have been described more or less in detail.

Owing to reports brought in from year to year by prospectors and others concerning minerals in the outlying districts, a more extended knowledge of the territory seemed desirable, hence I was instructed to examine the country in the vicinity of the upper Pelly river, and subsequently carry on an exploration across the mountains to the Mackenzie river.

I was accompanied throughout most of the journey by two residents of the country engaged at Dawson: namely, R. B. Riddell, and J. M. Christie. It is impossible to speak too highly of the services rendered by these men; suffice it to say here, that owing to their skill, energy and foresight, an expedition, which in less capable hands was liable to be attended

* Gravel River is now known as Keele River. (H. S. B., 1956.)

† This was published as a separate in 1910, Publication No. 1097. (H. S. B., 1956.)

by disaster at any stage, was carried through in safety and comparative comfort.

Through the courtesy of the Yukon government, the services of Mr. Robert Henderson- assistant to the territorial mining engineer—were placed at our disposal during the summer of 1907. Mr. Henderson did some careful prospecting, and collected specimens on the Pelly, Hoole, and Ketza rivers, and on several creeks.

From July 1, 1907, until July 20, 1908, was spent in the field, only a portion of this time being spent in actual survey work. Inactivity through stress of weather; the labour incident to travelling through a mountainous country, and the necessity of procuring a portion of our food from the region passed over, consumed the remainder of the time.

The early part of the summer of 1907 was devoted to an examination of the main Pelly, for a distance of 140 miles above its confluence with the Ross river; the object being to gain a knowledge of as much of the topography and geology in that direction as time permitted; also to inquire into the truth of a report brought down by some trappers of the existence of an active volcano in that region, and if possible to trace out the Pelly river to its source.

After overlooking the region from several mountain tops, and examining the bedrock and stream gravels for evidence of recent volcanic rocks, the conclusion was forced upon me that there was no truth in the statement.

The course of the Pelly river could be traced for a considerable distance beyond the point at which I turned back, and up to which an actual survey was made. Afterwards, during the winter journey, the source of what is believed to be the main Pelly river was seen from a hill near the head of the Ross river, the drainage being placed on the map provisionally, according to these observations.

Before setting out on the journey, it was decided to use the Ross river—one of the main tributaries of the Pelly—as a route most likely to lead across the summit of the Mackenzie mountains to the head-waters of the Gravel river, which flows into the Mackenzie. This surmise subsequently proved correct; for, after following the Ross river nearly to its source, a gap was found in the mountains, about five miles in length, and containing the divide. After passing through this gap a small stream was found at its northeastern end, which proved to be the extreme head of the main branch of the Gravel river. The unnavigable portions at the heads of the Ross and Gravel rivers and the divide, were passed over during the late winter; the necessary outfit being hauled on sleds by three dogs, in relays—the distance being about 100 miles.

We were entirely thrown upon our own resources after leaving the mouth of Ross river. During the journey we built two boats and one cabin, and, until the Mackenzie was reached, saw no person except a small band of wandering Indians at the head of the Gravel river.

This report is to be regarded only as a first contribution in a study of the geology and topography of the Mackenzie mountains, from observations made on a single line across their greatest width. The method by which the survey was carried on varied with the conditions and exigencies of travel. A micrometer and compass survey was made of the portion of the Pelly river examined, together with sketches from transit bearings on some of the mountains along its course.

The survey of the Ross river to Lewes lake was made by estimating or pacing distances along the river bank, and compass bearings.

From Lewes lake to our spring camp on the Grand river, the distances were measured by a 100-foot steel tape, and compass bearings; sketches, and bearings on prominent mountain peaks with the transit, being taken at intervals.

The Gravel river was surveyed partly by micrometer and compass, and partly by estimated distances; but in addition to this, mountain peaks were occupied at intervals of six to ten miles along its course, from which sketches of the neighbouring country were made, using transit bearings.

Differences of elevation were measured by careful readings of two reliable aneroid barometers.

On the map that accompanies this report, the Pelly river from Ross river to Campbell creek was taken from Dawson's survey in 1887; and the portion of the Mackenzie river shown is from Ogilvie's survey of 1888. The Macmillan and Stewart rivers are from surveys made by the writer in 1902 and 1905. Where the streams are shown by dotted lines, the drainage is known to exist; but has not been surveyed.

Only such features as can be shown on such a small scale are placed on the finished map, a fairly comprehensive idea of the relief of the region being expressed by means of approximate contour lines placed at vertical intervals of approximately 500 feet. The map is by no means an accurate one; but it will prove a reliable guide for the use of future travellers in that country.

Historical

In 1887, Dr. G. M. Dawson* made a journey from the Stikine river to the Yukon, following the Liard, Frances, and Finlayson rivers. Crossing the Pacific-Arctic divide at the head of the latter river, he reached the banks of the Pelly a few miles above the mouth of Campbell creek, and descended that river to the Yukon.

In Dr. Dawson's report is an account of the first exploration of the Liard and Pelly rivers in 1840, by Mr. Robert Campbell, of the Hudson's Bay Company. Mr. Campbell named the Pelly river after Sir H. Pelly, a governor of the company, and the Ross river after Chief Factor Donald Ross.

In the winter of 1893, Mr. Warburton Pike** crossed from the Liard river to the Pelly lakes, by way of the west arm of Frances lake and Ptarmigan creek. When the spring opened he descended the Pelly and Yukon rivers to Bering sea. The published account of his journey contains a map of the Pelly lakes and vicinity, and a short account of the geology by Dr. Dawson, based on rock specimens brought out by Mr. Pike.

The years 1897-8 saw great numbers of people—attracted by the newly discovered rich gold field of the Klondike—travelling over various routes to reach that desirable goal. Owing to a defective knowledge of the geography of the country, many attempted to reach that field from the valley of the Mackenzie. Of the thousands who chose that route, several died, the greater number turned back, but a persistent remnant filtered by various passes through the mountain barriers into the Yukon country. Of the latter,

* G. M. Dawson. The Yukon District and British Columbia, Ann. Rept. Geol. and Nat. Hist. Survey of Canada, Vol. III, Part I B.

** Warburton Pike. Through the sub-Arctic Forest. Edward Arnold, London, 1896.

was a party which started from Fort Norman on the Mackenzie river in the month of November, 1897, hauling their outfits on sleds, under the guidance of an Indian. They followed the Indian trail to the Gravel river, and went up the Twitya river to the divide. After crossing the divide they followed one of the branches of the Hess river, reaching boating water on this stream in April, 1898, and descended the Hess and Stewart rivers to the Yukon. Little was learned from their experience besides tales of hardships endured, except the fact that they crossed the divide through a low pass containing several small lakes which were at least 1,000 feet below timber line.

During the season of 1902, Mr. R. G. McConnell[1] and myself made a reconnaissance survey of the Macmillan river and a portion of its main branches, to within about eighty miles of its source.

In 1905, I[2] explored the Stewart river as far as the Tasin mountains, and during the same year Mr. C. Camsell[3] crossed the divide and surveyed the Wind and Peel rivers.

Previous to the present exploration nothing was known of the upper Pelly, the Ross, and Gravel rivers, and the great area which they drain.

Some of the early explorers who travelled down the Mackenzie, noted the mouth of the Gravel river in passing, but there is nothing more concerning it in their journals, with the exception of Mr. A. H. Murray,[4] of the Hudson's Bay Company, who mentions it as a probable route from the Mackenzie to the Yukon waters. He, however, ascertained from some Indians who knew the country, the impossibility of using such a route.

The name of the river appears to have been given by the fur-traders, from the number and extent of the gravel bars on its lower reaches. The Indian name for the main river is the Bacotyeh, signifying the "meat drying river", and the north branch they call the Twitya, or the "river that flows from a lake".

Indians

A small band of Indians, numbering about 110, including men, women and children, inhabit the country in the vicinity of the Ross and Pelly rivers. These people trade their furs with Messrs. Lewis and Field, who established a small trading post at the mouth of the Ross river about 1900. Previous to this they traded at the distant Hudson's Bay Company's upper post on Liard river. These Indians have always been careful during their hunting expeditions not to approach too closely the headwaters of the Ross or Pelly rivers on account of evil spirits, in the shape of gigantic Indians, who were supposed to inhabit the mountains about the divide.

About 100 Indians hunt and trap on the Gravel river and its branches, trading fur and dried meat at the Hudson's Bay Company's post at Fort Norman. They are called the Mountain men in distinction to the Indians who hunt on the plains around Great Bear lake and trade at the same post, and are a superior class of men to these or the Pelly Indians. The Mountain men and their families generally leave Fort Norman in September, walking over a direct trail to the Gravel River valley, up which they trap and hunt. Sometimes during the late winter they cross the divide, to the headwaters

[1] Summary Report of the Geol. Survey of Canada, 1902.
[2] J. Keele. The Upper Stewart River region, Yukon.
[3] C. Camsell. Peel River and tributaries, Yukon and Mackenzie.
[4] A. H. Murray, Journal dated Youcon, May 1, 1848. Bulletin of the Archives Branch, Ottawa.

of the Stewart, Macmillan, and Ross rivers, where certain kinds of fur are more plentiful. In the spring they return to the Gravel river and build mooseskin boats, in which they descend that river to the Mackenzie. The Mountain Indians have hunted on the Gravel river for a long time; there are meat-drying racks everywhere along the stream banks. Some of their signs are very old, showing evidence of stone implements having been used.

It was probably a long time before they grew bold enough to cross the divide, but even now they are careful not to go far down the streams on the western slopes for fear of meeting the fierce Yukon Indians; so that mutual fear and distrust have established a dead line over which representatives of neither side pass.

The white trappers who came up the Yukon tributaries in the years following the Klondike rush, having no traditional fears, made large catches of marten and beaver in this avoided territory.

In 1898, Mr. Frank Braine brought a party of Indians from Fort Good Hope, across the Mackenzie mountains, and established them on the Stewart river at the mouth of Lansing river. He erected a trading post at this point, bringing up his supplies from Dawson every summer.

The Indians on the Peel and Wind rivers have gone over the summit to Dawson to trade of late years, instead of to Fort McPherson as formerly. So that gradually the evil repute of this great mountain divide is passing from the life of the Indians.

The Indians, unfortunately, are not thriving; disease yearly decimates their thin ranks, and even the picturesque and hardy Mountain men are succumbing under its dreadful influence.

Topography

General Description

The highlands which lie between the Yukon and Mackenzie rivers are a portion of that great mountain system known as the North American Cordillera, which forms the western border region of the continent.

Two of the well-known topographic types that exist in the better known southern portion of the Cordillera have their northern counterpart in this region.

The country of comparatively low relief bordering the Lewes and Yukon rivers, to which the name Yukon Plateau has been applied, corresponds in position and topography to the Interior Plateau region of British Columbia.

The higher and more rugged mountains to the east, which form the water-parting between the upper Liard and Yukon on one side, and the main Mackenzie river on the other side, represent the northwestern continuation of the Rocky mountains proper. The name Mackenzie mountains is given to this portion of the system.

The Mackenzie mountains appear to be well defined; their axis is crescentic, the southern point lying in the valley of the Liard river, and the northwestern extremity reaching the lowland between the Yukon and Porcupine rivers.

It is the greatest mountain group in Canada, and appears to consist of two ranges, an older western range, against the eastern edges of which a newer range has been piled.

The names Selwyn range and Ogilvie range have been applied in former reports and on previous maps, to cover a considerable portion of these mountains. It has been found impossible to define the limits of these subdivisions, on topographic grounds, hence the name Mackenzie mountains has been given to the highlands as a whole. The name Selwyn mountains has been restricted to the mountains lying between the forks of the Macmillan river and Hess river, but it remains for future investigators to assign the proper limits to the Ogilvie range.

A number of important rivers have their source in, and flow for considerable distances through the Mackenzie mountains. Draining the eastern slopes and falling into the Mackenzie are the Nahanni, Root, Gravel, Carcajou, Arctic Red river, and Peel river. On the western side and tributary to the Yukon are the Pelly, Stewart, Klondike, and Chandindu; while the southern and southwestern slopes are drained by branches of the Liard.

The western front of the Mackenzie mountains merges into the Yukon plateau at various localities, so that it is often difficult to define the border line between these two topographic provinces. Several detached mountain groups are so well separated from the main range that they have been treated on former occasions as distinct features, and they are also described accordingly in the following pages.

On account of structural differences, the eastern portion of the Mackenzie mountains is more capable of subdivision as regards topographic features than is the western side.

There are two, or probably three parallel ranges which cross the Gravel river, trending in a northwest-southeast direction, with crests dominating the country on each side of them.

On Père Pettitot's map,* published in 1875, the mountains flanking the western side of the Mackenzie river are designated the Sa-yunne-kwe or Ti-konan-kkwene, signifying 'rocks of the bighorn' and 'backbone of the earth'. These names, with a slight variation in the spelling, have been adopted for two of the ranges.

The Sayunei range crosses the Gravel river at its junction with the Natla, and the Tigonankweine range crosses below the mouth of Twitya river.

Yukon Plateau

Bordering the Lewes, Yukon, and lower portion of the Pelly rivers, is a broken upland country in which hills, valleys, ridges and mountains succeed one another in an irregular manner and without system. A spectator, standing on one of these hills at an elevation of 2,500 feet above the river, sees flat-topped or dome-shaped hills, connected by a multitude of long, level or gently-sloping ridges, the whole forming a fairly even sky-line. Overlooking the depressions in which the drainage channels lie, the observer could conceive the tops of the ridges and hills to indicate the remnants of a former plain, of a rolling or undulating character.

The assumption here is, that a plain of such a description once stood at a much lower elevation, but has since been uplifted. The effect of the uplift was to increase the erosive power of the streams over the area, and consequently to cut the plain to pieces, thus evolving the present type of topography.

In the vicinity of the Yukon and Pelly rivers the flat-topped summits

* Bulletin de la Société de Géographie, Paris, 1875.

of this region have a general elevation of about 2,500 feet above the rivers, or about 4,000 feet above sea-level.

The principal valleys within this area have gently-sloping walls, with a tract of fairly level lowland a few miles in width bordering the rivers. These strips of lowland along the main rivers constitute the only available land for agricultural purposes in the region.

The higher portions of the plateau are covered with grass or scrub, while dark green coloured groves of spruce partly cover many of the bottom lands and extend a considerable distance up the slopes of the valleys. In many places level terraces follow along the sides of the hills, forming wide and easy steps, which are usually thinly wooded with poplar or small pine or covered by a rich grassy turf. In fact much of the Yukon plateau resembles the attractive foothill region east of the Rocky mountains, in the Province of Alberta.

Plateau Ranges

The Pelly river flows through the plateau region, from the mouth of the Macmillan river to the Yukon, a distance of seventy-five miles. East of this point is a belt of broken and rugged country, but with mountains of Alpine character, whose higher peaks rise to a height of 7,000 feet or more above sea-level. These mountains, which roughly trend northwest, are groups rather than a continuous range, being often widely separated by extensive low-lying drainage channels, or by stretches of hilly country of low relief.

Several of these mountain groups are known by distinctive names—the Pelly and Glenlyon mountains border the Pelly river to the south, and the Macmillan, McArthur, and Kalzas mountains lie to the north of the Macmillan river.

The change from the plateau region to the more rugged type of mountains is generally by a gradual transition, but in some instances these rugged masses rise from the plateau as from a pedestal, hence the name plateau ranges is used here for purposes of description.

Spurs from the main ranges lying to the east approach close to these plateau ranges, so that it is often difficult to define the western border of the former, especially as the same type of mountain and a similar topography exist in both divisions.

The valleys that branch in all directions through the plateau ranges are generally basin-shaped, having broad alluvial flats bordering the rivers, and easy side slopes reaching to the summits.

It has been suggested by Dr. Dawson that these isolated mountains may represent the remnants of a former range, having an axis nearly parallel with the main range, and antedating it as a physical feature. But since several of these mountain masses are known to have granite cores, which harden the sedimentary rocks in their vicinity, and the great thicknesses of argillites in the country rock elsewhere are easily weathered, their isolation may be due to prolonged differential erosion, acting on a generally uplifted and deformed region.

The Pelly and Glenlyon mountains, however, are more widely separated from the main range than any of the other groups, by a belt of plateau country—rather higher in elevation than the Yukon plateau—which extends southward from the Pelly river, embracing the upper Liard and the Frances rivers. There is not sufficient knowledge at present concerning these mountains, to state their relationship to the plateau or the main ridge with any degree of certainty.

Mackenzie Mountains

The high, rugged mountains, farther up the streams, east of the flanking groups, and including the divide, present a fairly massive front, with no important lowland areas breaking their continuity.

The crest line of these mountains is uneven both in course and in profile, for included within them are groups of mountains of a more subdued type, and many wide, branching valleys, that are trenched well back to the main divide. The structure is characterized by folding, generally on a broad scale, which has thrown the strata into a series of anticlines and synclines; but the folding is sometimes close, and in certain cases the folds appear to be overturned and overthrust. Many structural details, however, are concealed by the easy, well-wooded valley slopes, but the outcrops for long distances on the rivers often show steeply-inclined beds of the same kind repeated at intervals.

The topographic features are governed to some extent by the geology, for although the main drainage ways, as adjusted at present, cut across hard and soft strata alike, many of the wide valleys are carved out of the soft strata, while the higher ridges and peaks are formed of the uplifted hard beds. The highest peaks and the ones displaying the most rugged crests are built of granite stocks or pillars, which from their hardness, and greater resistance to weathering, continue to stand above the surrounding sedimentary rocks.

The surface features in general, are those which result from long-continued differential erosion, acting on a generally uplifted and deformed region. Certain modifications have been introduced by glacial action, such as the smoothing of inequalities in the bedrock, and the flooring of the main valleys with drift, thus submerging the lower slopes of the mountains. The lakes and ponds of various size which so often occur in the valleys, owe their origin, in many cases, to glacial action.

The higher mountain peaks of this region often exceed 7,000 feet in height above sea-level, and a few isolated peaks probably measure 8,000 feet, while the summits of many of the groups associated with them do not exceed about 6,000 feet, the vertical relief being from 3,000 to 4,500 feet.

The summit of the Christie pass, between the heads of the Ross and Gravel rivers, stands at a considerable elevation, being about 4,525 feet above sea-level, but there are routes on the Macmillan and Stewart rivers, leading to the Mackenzie waters, which are said to traverse valleys lying well below timber-line, containing small lakes and an ill-defined water parting at the divide.

The mountains in the vicinity of the watershed are not higher than many of the groups situated at considerable distances from it, so that the divide is not the most important element in the relief of the region, and does not form a natural division line separating the eastern and western slopes as distinct topographic provinces.

The development of valleys at the headwaters of streams is further advanced on the western side of the divide, this advantage being probably due to the greater amount of precipitation, and consequently the greater erosive power exercised on that side.

About forty miles east of the divide the topography changes in a marked degree, and a more compact and rugged mountain region is entered. The drainage channels of this region are confined in narrow valleys, with steep, barren slopes of rock and talus, the rivers in the bottom flowing in a very contracted bed, which at rare intervals opens out into a narrow alluvial flat.

The structure of these mountains differs from that of the ranges to the west, being apparently due to fracturing, buckling and faulting of the strata, and the residual masses present the appearance of a series of faulted and tilted blocks. The principal lines of fracture are in a northwest-southeast direction, and the beds have a prevailing southwesterly dip.

Escarpments produced by tilted strata, overlooking fault valleys, are the most prominent features, but they do not appear to persist in alignment for any great distance.

The highest peaks are roughly pyramid-shaped masses, carved from the harder of the stratified rocks of which the mountains are built. They vary in elevation from 6,500 to 7,500 feet, with a height above Gravel river of 3,500 to 6,000 feet. The denudation of these mountains has not reached such an advanced stage as that exhibited by those to the westward; the valleys are narrow and steep-sided, and the grade of the drainage channels is much steeper.

The Mackenzie mountains, as a whole, have a maximum width of about 300 miles; there is no well-defined crest line, but they appear to be rather a complex of irregular mountain masses, which are the result of deformation and uplift. The topography of the western portion bears evidence of long-continued differential erosion, while the eastern portion has the appearance of being in a more youthful topographic stage. Both in geology and structure the eastern portion of these mountains is closely related to the Rocky mountains in southern Canada.

Mackenzie Valley

On the Gravel river the high mountains approach to within a distance of about fifty miles of the Mackenzie river, and are then replaced by a belt of foothills about 3,000 feet in height above sea-level. These foothills in turn decline in elevation and finally die out in a broken, wooded plain, about 600 feet above sea-level, bordering the Mackenzie river.

About twelve miles eastward of the Mackenzie rises a narrow range of mountains, parallel to the river. These are known as the Franklin range. They are a spur of the Rocky mountains which crosses the Mackenzie river at latitude 62° 30′, or near the mouth of the Nahanni river. They attain their greatest elevation opposite the mouth of the Gravel river, the principal peak being Mount Clarke, about 5,000 feet. According to Père Pettitot, this range can be traced almost to the shores of the Arctic ocean.

Drainage

A portion of the drainage of the western slope of the Mackenzie mountains falls into the Frances river, and thence by the Liard and Mackenzie rivers into Beaufort sea, but the greater part is taken by tributaries of the Yukon river to Bering sea. All the drainage of the eastern slope falls into the Mackenzie river.

There is a great disparity both in river development and stream grades between the two sides of the divide.

On the western slope the water flows from near the divide, for a long distance, through valleys of mature erosion with an easy grade before reaching the master stream, the Yukon; while the streams on the eastern slope fall rapidly for a comparatively short distance and reach a much lower level at their junction with the Mackenzie. For example, the Ross and Pelly rivers have a combined length of 450 miles, and enter the Yukon at an elevation of about 1,500 feet above sea-level, while the Gravel river, 255 miles long, enters the Mackenzie at a height of about 200 feet above sea-level.

Owing to the great difference in precipitation the streams from the west side of the divide carry down to the Yukon more than twice as much water as the streams over an equal area on the eastern side. Thus the Gravel river and its branches do the work on the eastern side of the divide, while the combined efforts of the Hess, Macmillan, and Ross rivers are required to carry the water from the western slope; the Gravel river being about equal in volume to the Macmillan.

The higher mountains of the western slopes are more or less covered with snow during the greater part of the year, and receive a moderately copious rainfall; so that they are the gathering ground of numerous streams. These flow into the forks of the Pelly, Macmillan, and Ross rivers, which have a general southwest direction before joining the main stream. The greater part of the main drainage ways, therefore, lies transverse to the strike of the rocks, and to the trend of the mountains. The main Pelly river, however, flows in a general northwesterly direction, along the strike of the rocks, and in a valley flanked by parallel mountain ranges.

The time of flooding generally occurs early in June, when the rushing waters of the streams become powerful erosive and scouring agents, effectively removing the surface deposits of various kinds which floor the valleys, sometimes to great depths. These deposits, which consist of glacial drift and silts, form the banks of the streams, but an occasional spur of rock outcrops on the river.

In flood-time the water reaches far up the banks, sapping and undermining them, and the rivers, with the greatly increased current due to their swollen condition, quickly carry away the material that falls in, so that the rivers are constantly widening the trench in which they flow. There is a certain amount of constructive work done, as bars and new islands may be built up or banks made higher, but the whole process is a continual shifting of material from one point to another down stream.

As the rivers shrink in volume, long beds or bars, composed of the coarser pebbles derived from the banks, are exposed along the water's edge, and the water unable to attack the friable banks becomes clear; then the rivers cease to be active agents of erosion until next flood-time.

During the winter the rivers shrink considerably in volume, being fed altogether from underground water. In some of the small branches, water from a local source is liable to overflow the ice at intervals, and promptly freezing after each overflow builds up a considerable thickness of ice, which may extend down stream for miles. The remains of these icefields, often 10 feet in thickness, may be seen in July.

In spring, the small side streams are the first to open, then the pressure from the increase of water in the main streams arches the ice-sheet, and finally breaks it up. The broken ice usually jams at some point lower down, the pent-up water behind the jam breaks out again, and sweeps the river clear of ice. This operation is repeated until the entire river is open, no ice being left at the margins.

After the ice goes out there is generally low water in the rivers until the summer floods come.

The small lakes which occur at intervals on the Ross river are features not possessed by any of the other rivers, for although lakes of various sizes are of common occurrence in the valleys of the region, they are not situated directly on the main drainage system, but drain into them by brooks.

The lakes on the Ross river are shallow basins, a few miles in extent, and not more than 45 feet in depth. They are gradually being filled by sedimentation, and their level lowered by cutting down at the outlets; so that if present conditions continue undisturbed they will in time be obliterated.

The Gravel river on the eastern side of the divide is a vigorous stream, still in its youth, but sufficiently developed to have eroded its bed for the greater part of its course to a fairly even grade. It gathers a considerable volume of water in its early stages, and flows in a general northeast direction to join the Mackenzie.

From its source at the divide, to the point at which it leaves the mountains, the river scours bedrock in a continuous rapid, or flows over boulders which are too large to be carried.

The Gravel river receives three large tributaries—having a slightly higher grade than the principal stream—which probably head at the main divide.

The principal streams are independent of rock structure, and except in a few minor deviations flow across the strike of the rocks; but most of the smaller streams, conforming to the trend of the rocks, enter the main streams at right angles, thus producing a rectangular system of drainage.

The side streams are all steep and carry down a great deal of debris to the main stream, which, owing to its high grade and volume is able to handle all the material delivered to it.

As the river leaves the high mountains it drops some of its load, due to a slight decrease in velocity, and not having time to sink a bed in this material, the river flows across it, and splits up into several smaller channels. On entering the plain bordering the Mackenzie there is a further deposition of load, and as the river now has room to spread out, it forms a network of channels, about a mile wide, all flowing swiftly around gravel bars. These bars are nearly all composed of coarse gravel and small boulders, the fine material being all swept down stream, the amount of the latter material carried by the stream exceeding the amount of coarse material deposited.

There is very little decrease in velocity as the Mackenzie river is approached, and the Gravel river finally rushes into the greater river, with an impact that carries its water and sediment several hundred feet into the latter before it is brushed aside by the flood of the great river.

The Gravel river has built up an alluvial flat at its mouth, and several alluvial islands in the Mackenzie below this point are probably due to the great load of sediment carried in at flood-time.

A rough measurement of the Gravel river above its mouth, taken on July 19, gave a width of 700 feet, a middle depth of 8 feet, and a surface velocity of five miles an hour; the approximate discharge being 25,000 cubic feet per second. It is probable that the river shrinks greatly in volume by the end of August, as the snow is then almost completely gone from the mountains, and the rainfall is very light.

There are no lakes in any part of the valley of the main Gravel river, and none were seen from any of the mountains overlooking its tributaries.

Climate

The region lying between the Yukon and Mackenzie rivers possesses, as a whole, an extremely variable climate within the year, while the topographic provinces included within this area exhibit certain climatic differences; the peculiarities being chiefly as regards precipitation.

The Yukon plateau, protected from the prevailing westerly winds by mountain ranges from 5,000 to 10,000 feet in height, has an arid climate, very little wind, and temperature ranging from 80° in June to −60° in January.

The western slopes of the Mackenzie mountains, of higher elevation and exposed to the prevailing winds, have a comparatively high precipitation, and periods of high winds, while the eastern slopes being on the lee side receive a small precipitation, and immunity from the high winds. The average monthly temperature, however, does not vary much over the three provinces.

June is a perfect summer month with practically no darkness, and on fair days nearly twenty hours of bright sunshine; the temperature sometimes reaches as high as 90°.

January is the coldest month of the year, with about five hours' sunshine on unclouded days; the temperature seldom rises above zero, and for several days is down to −60°, or lower.

Three months of the year, from May 25 until August 25, are practically free from frost in the valley bottoms.

July, August, and September are the months of greatest rainfall, which is scanty over the Yukon plateau, being only about 7·5 inches in the year. There are no recorded measurements in the mountains to the eastward, but it is probably not less than thirty inches annually.

The greatest amount of snow falls during the late autumn and early winter. In March, 1908, the snow was five feet deep in the valley of the Ross river near the divide, but on the Pelly river it would not be more than half that depth at the same time.

On the east side of the divide the snowfall is light, being three feet less than on the west side in 1908.

On and after September 1, fresh snow begins to appear on the mountains, while rain is falling in the valleys. The first few falls of snow generally disappear from the valleys, but remain on the mountains, consequently there is a much greater accumulation of snow there.

The small watercourses begin to freeze about the middle of September; the ice begins to form on the larger streams early in October, and they are generally closed by the end of that month.

The water becomes very low in winter, the streams being fed altogether from underground sources, and very little erosion of any kind goes on then, as no rock fragments or debris of any kind were seen on the snow slopes on the mountains.

In the lengthening days of May the snow begins to disappear in the valleys, principally by insolation and evaporation, and by the first of June very little remains except on the mountains.

The rivers open between May 10 and 20, and flood-water comes down early in June, after which a period of high water continues until about the middle of July, or later if the season is a rainy one.

Owing to the thawing of the frozen ground, there is considerable moisture in the mountains above tree line, even after the snow is gone. This water collects in pools or runs down the slopes in rills, carrying a certain amount of rock waste to lower levels.

When mountains become low enough to permit a growth to cover their summits the protection thus afforded by tree, shrub and moss keeps the frozen ground beneath from thawing, so that those mountains are practically at a standstill as regards sub-areal denudation, and can only be attacked by headwater stream erosion.

The effect of insolation in east and west lying valleys is well marked in the difference presented by the aspect of the valley slopes. Those facing the south are generally of easy and uniform grade, with large, open, thinly-wooded tracts, or bare ground; while those facing northward have steeper declivities, which are closely wooded or moss covered.

On account of the long period of sunshine during the days, nearly all the snow disappears from the Mackenzie mountains before the summer ends.

Vegetation advances very rapidly in summer, and where the soil is good, vegetables of many kinds may be grown along the river banks in the principal valleys.

Small fruits, such as raspberries, blueberries, red and black currants, and two varieties of cranberry are abundant and of good quality.

The change from an arid climate to one of greater humidity is apparent by the growth, to any one ascending the Pelly river. The lower part of this river is very attractive in appearance, the valley being bordered by open, grassy terraces, and the immediate banks of the river bearing groves of tall white spruce. This aspect disappears on the Ross river, where a ragged growth of white and black spruce covers the banks and the valley bottom, and the slopes are covered with a thick carpet of moss, under a light growth of black spruce, interspersed with willow and alder swamps.

In passing over the divide an arid region is again reached on the lee side of the mountains, where growth is sparse and the soil is of poor quality.

Tree growth extends to within a short distance of the summit of Christie pass on the western side, but on the eastern side trees are not seen until a descent of about 900 feet is made.

Fauna

The Yukon territory contains some of the best sections of game country in Canada, and many trappers and prospectors have been able to live for long periods almost entirely on the proceeds of the rifle and net.

Of late years, however, game of all kinds has become very scarce in some localities, owing to the extensive killing carried on by those who hunt for the market offered by mining camps.

The Indians having lately acquired high-power magazine guns, are responsible for a great deal of slaughter, as the average Indian who gets into a band of big game shoots as long as his cartridges hold out, whether he can use the meat or not. Head hunters who come into the country in search of fine specimens, do a great deal of damage, as they have been known after a day's hunting, to leave enough meat to spoil on a hillside to supply a prospector with provisions for a whole winter. These men at the end of their hunt will take out about twelve heads each, which would mean the killing of twenty animals.

The moose is the chief game animal, and is still plentiful in the valleys of that part of the Pelly river and its tributaries which flow through the Mackenzie mountains.

Almost any fine day in summer, from the top of a mountain, a few moose can be located in the valleys below, by the aid of a pair of field-glasses.

The valley of the Ross river affords a good range for moose, as it is sprinkled with numerous small lakes, and several extensive willow patches, which furnish the most desirable food and environment.

There are a few moose scattered along the valley of the Gravel river, but it is not a good moose country, as there are no small lakes, and on account of the narrow valleys, and low timber-line, the area over which they can feed is restricted.

Cariboo are found in small bands on some of the mountain groups on the Pelly and Macmillan rivers. They select mountains of a subdued type, having large expanses of tableland, and as long as their favourite moss is plentiful do not leave that neighbourhood unless forced to.

It is true that cariboo collect in large numbers in the northern part of the Mackenzie mountains, and moving herds were frequently seen on the headwaters of the Klondike river, but there is no such herding or movement on the part of the small bands on the Pelly branches.

Cariboo were observed only at one locality on the Gravel river, near the edge of the first timber, about twenty miles from the divide.

The mountain sheep are in small scattered bands, and inhabit only a few selected mountain groups. They require a feeding ground above timber-line, from which the wind blows the snow in the winter time, and convenient crags to afford a place of retreat from enemies. During the summer the sheep venture down to the valleys, in search of alkaline clay, which they desire to lick at certain periods; but for the most part they keep above timber-line.

The sheep on the Stewart river are all pure white, while those on the Macmillan and Pelly rivers range in colour from white to almost black.

Sheep are plentiful on parts of the Gravel river, particularly on the low mountains between the Sayunei and the Tigonankweine ranges. Among the hundreds of sheep seen by the writer in this locality none but those with pure white wool were observed.

The sheep are highly prized for their heads, and on account of their flesh, which is the best of all the wild meat, consequently they are hunted to extermination in any of the accessible localities.

Black, brown, and grizzly bears are more or less numerous, but are not often met with, except in the month of August, when they come out along the banks of the Yukon tributaries to feed on the salmon.

Black and grey timber wolves are scattered throughout the region, but they are very rarely seen during the summer months. In winter they assemble in packs, and make regular hunting trips up and down the valleys, killing large numbers of moose.

The salmon come up the Pelly river and its tributaries about the latter end of July, reach the spawning grounds in August and are all dead by the end of that month.

Thousands of salmon in all stages of decay were lying along the bars and on the bottom of the Ross river, when we descended that stream in August.

Whitefish, inconnu, and pike are found in greater or less abundance, in all the streams and lakes in the region. A net set in any favourable place rarely fails to take some of the above varieties.

Grayling were plentiful on the Pelly river, and numbers were easily taken with a rod and line, using an artificial fly for bait.

Grayling, herring, and a variety of brook trout were the only fish found in the Gravel river, there being an abundance of grayling; but herring and trout were rarely taken.

Great numbers of wild geese breed along the main rivers tributary to the Yukon, the nesting sites and feeding ground being among the willows and on the mud bars close to the streams. Scattered pairs of swans frequent the small lakes in the wide valleys during the summer, but they gather in large flocks in the late autumn before taking their departure to the south. The geese and swans do not frequent the Gravel river, as the conditions there are unsuitable.

Fur Trade

Furs are the principal articles of value at present derived from the Pelly river and its tributaries.

During the year 1898, and the few following years, numbers of white men ascended these rivers in the search for gold, but never succeeded in finding it in paying quantities.

Some of these men, attracted by the great extent of country in which fur-bearing animals were found to be numerous, settled temporarily in the country to make a living by trapping.

The few that still keep up the search for gold are forced to spend considerable of their time in trapping and hunting as a means of subsistence.

The following estimate by Mr. R. B. Riddell, who trapped for several years on the Macmillan river, gives an approximate idea of the value of the furs taken on the Pelly and Macmillan rivers:

Year	No. of Trappers.	Kind of fur.	Value.
1901	15	Principally marten	$ 7,000
1902	40	" "	15,000
1903	50	" "	20,000
1904	50	Marten and lynx	18,000
1905	30	Principally lynx	8,000

There were also a small number of beaver, wolverine, and fox taken each year, and included in the above estimate.

The Indians take nearly an equal amount of fur, making a total for the Pelly trade during the above five years of $136,000.

In 1904, lynx invaded the Pelly region, coming from the south, and disappeared during 1907, moving northward.

The marten disappeared soon after the arrival of the lynx; they returned in 1907 to the parts of the region not frequented by lynx, but in this year both marten and lynx are reported as being very scarce.

The movements of the lynx were probably governed by their food supply, because in the years previous to 1904, rabbits were extremely abundant in the Pelly country, and the lynx appear to have followed the rabbits. In the following years the number of rabbits steadily declined, and in 1907 they had practically disappeared.

While the movements of small carnivorous animals are governed by food supply, their disappearance from a certain locality can often be accounted for by the fact that they are trapped almost to extermination.

The Indians seldom trap a locality out, as they are forced to move their camps often in search of game, and consequently trap lightly over a large area.

The white man brings in most of his provisions, establishes himself in some chosen locality, builds a headquarters cabin, and a number of small outlying shelters, and devotes all his time to trapping, using steel traps as well as dead-falls. Consequently in a few years the fur in his neighbourhood diminishes to such a degree that he is forced to select new grounds or seek some other employment.

Forests

A monotonous growth of coniferous forest of varying density covers the bottoms of the valleys in the Pelly basin, and reaches far up the sides of the mountains.

The limit of tree growth averages about 4,500 feet above sea-level; it varies according to the aspect and nature of the slope.

The forest consists of white and black spruce, aspen and balsam poplar, black pine, balsam fir, and birch; and a few small larch were observed on the Pelly a few miles above Woodside river.

The principal tree is the white spruce, which grows at its best on the alluvial banks and islands on the lower part of the main rivers, where it attains a diameter averaging about 12 inches. Timber of this size is confined to a narrow strip on each side of the rivers; in the valley beyond this strip, the trees are smaller and of poorer quality, having an average diameter of about 7 inches.

A small quantity of timber is cut every year along the Pelly and Macmillan rivers, and taken down to Dawson in rafts, where it is sawn into lumber, but the supply of commercial timber is limited, there being only sufficient for local use.

The black pine grows only on a limited area, being confined to terraces along the lower part of the rivers; the trees do not exceed about 9 inches in diameter.

The balsam fir is found on the mountain slopes all the way up to tree line, but does not grow in the bottoms of the principal valleys.

Toward the headwaters of the streams the timber becomes smaller and more scattered. Except for a few stunted balsam at the southern entrance, the Christie pass is quite devoid of tree growth.

The valleys at the headwaters of the Gravel river are entirely bare of trees, the first timber met with after leaving the Ross river being fifteen miles beyond the watershed, and consisting of a meagre growth of black spruce confined to the river bank.

The balsam fir and black pine are absent on the Mackenzie slopes, but the larch extends up the valley of the Gravel river for about 150 miles.

The timber resources of the Gravel river are very moderate, the white and black spruce trees of any importance being confined to the alluvial flats, which on this river are very limited in extent, and the best white spruce groves average about 10 inches in diameter.

The height to which timber will grow on the mountain slopes varies very considerably in the Gravel River valley, but the average height is about 4,000 feet above sea-level. Generally very few trees grow higher than about 1,000 feet above the river, owing to the steep slopes of rock and talus of the valley walls.

The valley of the Mackenzie river in the neighbourhood of the Gravel river is sparsely wooded with an inferior tree growth.

Transportation

Small steamers of light draught and sufficient power can ascend the Pelly river, during high-water stages, as far as the mouth of the Ross river, a distance of 250 miles from the Yukon, or up the Macmillan river as far as the forks. At least one steamer comes up to Ross river every summer, carrying trappers and prospectors with their freight; also bringing supplies for a fur-trading post at this point. The charge on freight from Dawson is $50 a ton, and for each passenger $50; the journey can be made in six days, but usually takes longer.

The traveller who wishes to go further, either tracks his own boat up stream or walks across country.

Pack-horses could be used over a limited portion of the country, particularly along the open benches of the main valleys, but the wet mossy floor, the thick growth, and the scarcity of feed in the upper valleys would be found serious obstacles to their use.

Dogs are frequently used as pack animals by the trappers and Indians during the summer; a good dog will pack forty or fifty pounds. In winter most of the travelling is done on the rivers, with dogs hauling the necessary outfits on sleds or toboggans. If the loads to be hauled are heavy, the trail must be broken a day ahead to allow it to freeze hard enough to hold up the dogs.

It is quite possible to boat up the Pelly river, but with heavy loads it is a hard task, as the current is strong and steady and there are numerous stiff riffles. Two portages must be made, either going up or down stream: one at Hoole cañon of half a mile, and another at Wolf cañon of one and three-quarter miles, these cañons being, respectively, 23 and 143 miles above Ross river. Two rough bedrock rapids occur: Hoole rapid, just below the river of that name, and Slate rapid, about sixteen miles above Campbell creek. A boat with small load can be lined up both these rapids, on the west bank, and can be run with safety by competent boatmen coming down stream.

Beyond Wolf cañon the Pelly is navigable for small boats for a distance of at least forty miles.

About six miles of swift broken water is encountered on the Ross river, after leaving the Pelly. Above this there are about seventy-five miles of river with a moderate current, and several shallow riffles. Above this there is a stretch of twenty miles of swift water, in which occur four short rapids, past which goods have to be portaged, but the empty boat can be hauled up with the line.

Sheldon lake is the limit of boat navigation in low water, but in high stages of water, John lake, or even Wilson lake, might be reached, with light loads, and much labour. Wilson lake is about thirty miles from the divide, over a winter trail. Suitable water for boating on the Gravel river is reached at a distance of about thirty miles beyond the divide, and from this point to the Mackenzie the current never moderates, the river being swift throughout its course. The Gravel river is best descended at high water stages, when the larger boulders are covered and the rougher rapids drowned out. The Indians use mooseskin boats about 30 feet long, 6 feet wide and 4 feet deep, made of eight or ten mooseskins stretched over a stout green spruce frame.

It is practically impossible to take a loaded boat up the Gravel river.

The Hudson's Bay Company have recently placed a new steamer on the Mackenzie and Slave River route, which has accommodation for several passengers, as well as a good freight capacity. This steamer makes two trips each summer down the Mackenzie, on the first trip going to Fort McPherson on the Peel river, but on the second journey not farther than Fort Norman. On the first trip up stream this steamer connects with a regular line of transport to Edmonton.

Geology

General Description

The rocks which were found in the vicinity of the Pelly, Ross, and Gravel rivers may be divided into three main groups: (1) Stratified rocks, (2) Intrusive rocks, (3) Metamorphic rocks, the first group being by far the most widely distributed.

The term stratified rocks is used to include shales, slates, sandstones, conglomerates, limestones, dolomites and cherts, and beds of lava and tuff. Beds of these rocks occur interstratified with one another, and with few exceptions have been disturbed by various causes from the attitude in which they were originally laid down, the deformity of the beds being often extreme.

The intrusive rocks are mostly coarsely granular, being of a granitic character, and occur only in small bodies widely separated from each other.

The metamorphic rocks which result from the alteration of either of the others, have a wide distribution in some parts of the Yukon territory, but are limited to a small area on the Pelly river. They consist chiefly of schists and gneisses; the metamorphism is very pronounced, the original characteristics of the rocks being obscured by the development of new minerals and different structure. The term metamorphic rocks is used for this series, because it is descriptive of these rocks as a whole; in the sedimentary group there are also metamorphosed rocks, but the alteration in those is not usually so marked, and it seldom obliterates all clue to their origin.

The group of sedimentary rocks of which the Mackenzie mountains are built shows a generally different lithologic character on either side of the divide. The western portions of the mountains are composed of rocks which appear to have been laid down mostly as shallow water deposits, with frequent changes in the kind of material deposited, and under unstable conditions due to intermittent volcanic action. The processes of mountain building, and the intrusion of various bodies of igneous rocks have partly changed the original character of many of the beds in these sediments.

The sedimentary rocks on the eastern side of the divide are, for the most part, the result of sedimentation and precipitation carried on farther from shore lines and under conditions which were unchanging over long periods. The mountain building has not altered these sediments to any extent, and with one exception they were, wherever observed, entirely free from association with igneous rocks of any kind.

The main line of traverse followed from the Pelly to the Mackenzie was in a northeasterly direction, or across the trend of the rock formations, so that all the principal members of the rock groups were observed at some points. But there are large areas where no rock exposures were seen, this being the case in the lower part of the Ross river and during the winter journey across the watershed. The observations on the Ross river are supplemented by observations on the Macmillan and Stewart rivers made in former years, over similar rocks; observations on the eastern slopes are confined to the Gravel river alone.

Fossils collected at a few localities were sufficiently preserved to give a definite position in the stratigraphic column to the beds in which they were found. A brief account of the fossil fauna, and their relationship to the stratigraphy, as far as known, is given in the subdivision on stratified rocks.

Owing to incompleteness of data, in a region of folding and faulting, the writer is unable to give the proper sequence and thickness of the strata, and for this reason no local names are given to any subdivision because they cannot be defined at present as stratigraphic units.

Rock Formations and Distribution

The crystalline schists which occur on the Pelly river at many points from the Yukon up to Ketza river, are the most important rocks in the region, as placer gold is generally found associated with them. Above Ketza river they are exposed at only a few places, and are not seen at all beyond Campbell creek.

Their extension south of the Pelly is not known, but as they are found on Hoole river it is probable that they extend to the base of the Pelly mountains, and then trend in a southeasterly direction along the upper Liard and Frances rivers.

The crystalline schists are found along the Ross river for a distance of about twenty miles above its mouth. They consist in this locality of greenish and dark grey quartz mica schists, and actinolite or talcose schists, derived from both sedimentary and volcanic rocks.

The greater part of the schists are highly altered sediments, but associated with them are some basic igneous rocks which have been intruded along the bedding planes of the older formation and subsequently sheared and altered.

The various rock members which make up this formation have been subjected to such a high degree of metamorphism that their boundaries and original structure have been destroyed, and a schistosity common to them all has been developed.

The strike or trend of the rocks is generally northwestward, and they dip at various angles, the strata being broadly folded as a rule.

Quartz veins and stringers are numerous in places, but on the Pelly quartz does not constitute as large a portion of the rock mass as it does in similar rocks at other localities.

The crystalline schists have a wide distribution in the Yukon territory, and have been described in a few localities under the name Nasina series; the rocks in the area under consideration probably represent the same series.

Nothing is known of the age of these rocks, except that they are older than adjoining and overlying sedimentary rocks in which fossils of Ordovician age have been found, but they may be pre-Cambrian.

The contact between the crystalline schists and the Palæozoic rock has not been observed at any point where traverses were made from one to another.

The crystalline schists on the Pelly river are replaced in the vicinity of Ketza river by thinly bedded black and grey cherty quartzites, associated and interbedded with white marble.

Above the mouth of Campbell creek several masses of greenstone occur which are intrusive in the quartzites, and the marble is replaced by massive beds of yellowish weathering crystalline dolomite.

At Slate rapids, and for some miles above, grey argillites both of shaly and slaty varieties, with some limestone beds, form the banks of the Pelly river, the slates at the rapids being overlain conformably by several thick beds of chert breccia, which are made up principally of small fragments. The mountains above the mouth of Woodside river are made up of very compact laminated quartzite interbedded with schistose slates. The beds seen along the river assume all possible attitudes, and no fossils were found; so that from the brief examination given to them, it is impossible to state what the sequence is. Some slabs of black argillite containing graptolites were found among the gravel on a bar near Slate rapids, which would indicate that a middle Ordovician horizon exists somewhere in this vicinity.

On going up the Ross river, the black shaly argillites of False cañon, seventeen miles from the Pelly, succeed the crystalline schists, which were last seen a few miles below this point. Beyond False cañon the few exposures seen for the next fifty miles consisted of thinly bedded quartzites and argillites, similar to those on the Pelly river, or of small detached masses of diorite, and andesite.

A fairly continuous section, of about fifteen miles in length, seen along the river below Lewes lake, shows a remarkably complex series of closely folded rocks, with rapid alternation in bedding and composition. These consist of red, green and grey slates, or argillites, chert, quartzite, limestone, sandstone, grits, and volcanic tuffs.

No organic remains of any description were found in this group, but they are placed provisionally as Silurian, for reasons which are given further on.

The argillaceous rocks of the group are varied in colour, and in the degree of alteration, and exhibit a slaty cleavage at right angles to the bedding, or a shaly structure, where the beds are made up either of thinly laminated layers or of wedge-shaped fragments.

The most important limestone band in the series varies in thickness from 10 to 150 or 200 feet in thickness, in beds of 2 to 12 inches thick, and dark grey in colour.

The sandstones are made up chiefly of quartz fragments; they are very hard, and do not weather easily. A thin section under the microscope shows that the material has been crushed and strained prior to the consolidation of the rock, so that it is evidently derived from the erosion of the underlying crystalline schists.

The grits are made up of quartz grains about the size of corn, without much cementing material, and occur in rather massive beds which are well displayed in the walls of Prévost cañon. There are varying degrees of coarseness in these quartzose clastics, and they often occur interbedded with grey shales.

The strong red colour of some of the slates, and the rather remarkable quartz grits, have served to identify this group of rocks at the following widely separated localities: The Pelly river, in the vicinity of Wolf cañon; the Macmillan river, near Russell creek; and the Stewart river at Tasin mountains.

On the Ross river this group of rocks is succeeded and apparently underlain by dark grey argillites or black slates, cherts and quartzites; and the exposures from Lewes lake to the divide show a monotonous succession of these types.

A bed of black indurated shale from one of these exposures about seven miles below John lake contained graptolites of upper Ordovician age.

There is a great quantity of argillites and cherts with some dark coloured limestone on the upper part of the Macmillan river, which McConnell* places above the red slates and associated rocks, but they are similar in every respect to the Ross River rocks, above Lewes lake.

The beds of chert breccias which form a considerable thickness at the upper part of the section on the Macmillan river were not seen at all on the Ross river, otherwise the sections on the two rivers are very similar.

There is a wide band of thinly bedded black chert south of the red slate beds on both streams. Whether these cherts are part of the main area of similar beds which occur on the upper part of the streams or not, is doubtful.

On the Ross river the red slate and associated beds appear to lie in a basin formed by the cherts and argillites. On the Macmillan river the attitude of the rocks apparently indicates a descending series on going up stream, until the red slate beds are reached, but McConnell remarks that the regularity of the dip is probably due in a large measure to overturn folds and faults.

The mountains of the watershed at the head of the Ross river are formed of alternating beds of dark compact quartzite and grey shale and slate.

About ten miles east of the divide some yellowish crystalline limestones occur in low isolated cliffs along the embryo Gravel river, but the principal rocks are dark sandy shales, striped grey slates and micaceous sandstone or quartzose schists. Rocks of this character extend eastward to Mount Sekwi, about fifty miles from the divide, and then end abruptly.

The relationship of the rocks on the upper part of the Ross and Gravel rivers—including the divide—to the great body of cherts and argillites lower down the Ross river was not determined, and no fossils were found,

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* Summary Report, Geological Survey, 1902, p. 31.

but the striped grey slates included in them resemble those associated with the red slates and quartz grits.

A radically different geological province begins at Mount Sekwi, and limestones, dolomites, sandstones, and conglomerates, etc., of various bright colours, replace the sombre rocks to the westward.

The distribution of these rocks is at present known only in a very limited way, but it is probable that formations similar to those subsequently noted here, will be found to have a wide northwest-southeast extent on the eastern slopes of the Mackenzie mountains, from the Liard to the Arctic Red river.

The structure, the character and sequence of the strata, and the organic remains, all indicate that the eastern part of the Mackenzie mountains is geologically as well as physically the northern counterpart of the Rocky mountains, and that at least two series of rocks, the Bow River and the Castle Mountain groups of southern British Columbia and Alberta, are represented here.

Stratified Rocks

Palæozoic Strata

Cambrian. Purple and greenish argillites, in beds from a few inches to over a foot in thickness, are exposed at the base of the mountain, at the junction of the Natla with the Gravel river. Above the argillites are dolomites, calcareous sandstone and limestone; these beds have a total thickness of about 4,000 feet, and incline at a low angle to the southeast. The dolomites form a considerable portion of the section, the lower beds are white and crystalline, while those near the top are a striped grey colour. All have a soft yellow coating on the exposed surfaces. The limestone occurs in thin slabs containing fossils, is rather impure, and weathers to a bright yellow colour.

A small collection of brachiopods found in these beds was submitted to Dr. Ami, who referred them to *Billingsella* of Hall and Clarke, a form usually characteristic of the Cambrian system. Not having foreign material to compare them with, he sent them to Dr. Schuchert, of Yale University, who recognized the species to be '*Billingsella Coloradœnsis*', Shumard, usually referred to the middle Cambrian, but which has also been recorded in the upper Cambrian. The form *Eo-orthis desmopleura*, Meek, sp., was also identified in the same specimens.

Below the mouth of the Natla river the mountains are composed of rocks quite different from the foregoing, which dip up stream and appear to pass under them. This strata is made up in descending order of:

Brown micaceous sandy slates................	1,100 feet
Conglomerate..............................	2,000 "
Coarsely laminated hematite and siliceous slate..	100 "
Dolomite and argillite.......................	1,000 "
	4,200 "

No fossils were found in any of these rocks, and they were only seen along this portion of the river, being cut off by a fault at their northern end. The conglomerates form the wall rock of Shezal cañon.

These rocks from their position probably constitute the middle or lower portion of the Cambrian*, and probably correspond to the Bow River

* It is possible that they may be Precambrian.

series described by McConnell*, while the rocks found above the mouth of Natla river are referable to the Castle Mountain group.

Ordovician. That part of the Tigonankweine range through which the Gravel river flows is built up of rocks which are here included in the Ordovician.

Below the mouth of Twitya, on the north side of the Gravel river, the rocks lie nearly horizontal, the base of the section showing about 4,000 feet of alternating beds of argillite, dolomite, and limestone; above these are about 1,500 feet of sandstone. Just below the sandstone is a sill of diabase about 100 feet thick and several miles in extent.

Fossils were found in a thick bed of limestone on a mountain a few miles north of the mouth of Nidhe brook. Mr. L. M. Lambe reports the following forms from a small collection of fossil corals brought down from this point:

Favosites aspera ?, d'Orbigny.
Calapœcia canadensis, Billings.
Halysites catenularia, var. *gracilis*, Hall.
Columnaria rugosa, Billings.

Also a cephalopod, referred by Dr. Ami to

Actinoceras Bigsbyi, Stokes,

a form eminently characteristic of the Black River formation in eastern Canada.

The great development of sandstones in this section is remarkable. They get thicker going eastward, and opposite the mouth of Nainlin brook, they form, with only an occasional shaly parting, the entire mountain mass, or about 4,500 feet of horizontal strata.

The prevailing colour of the sandstone is reddish, but in several places it is grey, with rusty specks. The beds vary in thickness from a thin, flaggy variety up to 3 feet. The red sandstones are mostly indurated, some of the beds being changed to quartzite.

About seven miles below John lake, on the Ross river, a small collection of graptolites was obtained from some black indurated shale interbedded with cherty argillites, and cherts. Dr. Ami reports the following forms, and refers the beds containing them to the upper part of the Ordovician system:

Orthograptus quadrimucronatus, Hall.
Leptograptus flaccidus, Hall.
Orthograptus or *Glossograptus*, sp.

Silurian. The eastern part of Mount Sekwi, on the Gravel river, is composed of dove coloured limestones in beds, varying from a few inches to a foot or more in thickness, thrown into a vertical attitude.

The limestone beds pass into grey argillites, having slaty and schistose phases, and are interbedded with sandstone or quartzite.

The bulk of the limestones appeared to be unfossiliferous, but a small loose piece found on the mountain side contained some fossil shells, which proved to be a *Camarotœchia*, closely related to *C. acinus*, Hall; also part of a corallite of a *Cyathophyllum*.

Some distance east of Mount Sekwi the above beds assume a nearly level position, but gradually rise again until they are tilted toward the west at a high angle.

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* R. G. McConnell. Ann. Rept. Geol. and Nat. Hist. Survey of Canada, 1886, Vol. II Part D.

The section here shows over 2,000 feet of rather pure limestones, the bottom beds being of a compact dark grey variety; the beds at the top are light coloured, porous, and semi-crystalline, and some shaly and silicified beds occur at intervals.

A partly silicified bed of limestone near the top of the section showed a profusion of badly preserved organic forms, principally large branching corals.

Of the few of these brought out, Lambe reports the following forms:

Favosites, sp.
Streptelasma, sp.
Acervularia gracilis, Billings.

Also two specimens of a Stromatoporoid, *Actinodictyon Keelei**, described as a new species by Dr. Parks, and a Pentamerus, which was kindly examined by Dr. Charles Schuchert, of Yale University, New Haven, who pronounces it to be apparently an undescribed species, and nearest to *Papillosus*.

Devonian. The sandstones classed as upper Ordovician extend down the Gravel river nearly to Inlin brook, and are then replaced by limestones, more or less massive, but the contact with them was not seen. The limestone beds are broken into several faulted blocks, dipping to the southwest, with low escarpments facing the northeast, and here constitute the eastern foothills of the Mackenzie mountains.

No fossils were found in the limestones of the foothills, but they are probably lower Devonian. As the foothills decrease in altitude going eastward, the limestones become less tilted and broken, the bedding is thinner and several shaly layers appear. Brachiopods are abundant in some of these beds, particularly *Atrypa reticularis* (L.) and *Atrypa spinosa*, Hall, and the following corals which were determined by Lambe:

Streptelasma rectum, Hall.
Phillipsastræa verneuili, Milne-Edwards and Haime.
Hederella canadensis, Nicholson.

Mesozoic Strata

Fossils of Triassic age were found by the writer in some impure limestones, in the upper Stewart River region in 1905, and a large area of rocks was coloured as Triassic on a map of that region published a few years ago. Since then there has been reason to believe that these rocks are Palæozoic, and that only a small remnant of Triassic rocks was enfolded with them.

A similar case occurs on the Pelly river below the Ross river, where a small undefined area of rocks was found by Dawson to contain plants of upper Cretaceous age, but the different character of these rocks to the surrounding crystalline schists renders them conspicuous in this locality.

A few exposures of soft sandstone and conglomerate were found lying unconformably on the chert beds on the Ross river above Sheldon lake. No satisfactory examination of these could be made at the time, on account of the snow, but they are probably of Mesozoic age.

About twenty-five miles from the Mackenzie some soft sandstones and conglomerates are exposed for a few miles, along the north bank of the Gravel river; the beds are inclined slightly toward the west, and have a thickness of about 200 feet.

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* W. A. Parks. 'Silurian Stromatoporoids'.

The sandstones are coarse grained and nodular, of yellowish or grey colour, grading into fine conglomerates, which are made up chiefly of black cherty argillite fragments.

No fossils were found in these rocks, and although no exposures were seen below this point, they are probably part of the same series found on the Mackenzie river, in this neighbourhood, which McConnell refers to the upper Cretaceous.

The Cretaceous beds occupy the depression between the base of the Mackenzie and the Franklin ranges, and have a width of about twenty miles in the vicinity of the Gravel river. They overlie Devonian limestones and shales.

Tertiary Strata

The Tertiary rocks which occupy a basin of limited extent on the Mackenzie river at the mouth of Bear river, are described in detail by McConnell* in his report.

Basalt occurs in low bluffs, for a distance of about fifteen miles along the Pelly river near Hoole river. It is pre-glacial, and Dawson has classed it provisionally as miocene from analogy with similar deposits in British Columbia. Nothing further was learned of its age or origin by the writer.

Igneous Rocks

The unaltered igneous rocks appear in this region only as small isolated masses among the sedimentary or metamorphic rocks.

Granite was seen about ten miles up the Ross river, where it forms a ridge about 1,800 feet high on the north side of the river.

The rock is a fine-grained, brownish coloured, biotite granite, and is intrusive in the crystalline schists which are seen exposed around the base of the ridge.

This granite is different to the bodies which sometimes form the centre of the mountains in the sedimentary rocks, being finer grained and of a more acid type. It has been exposed to erosive influences for a long period, and the profile of the ridge is similar to adjacent ones composed wholly of sedimentary rocks.

Several importan bodies of igneous rocks occur as stocks, or cores, in the higher mountains, or mountain groups. Mount Sheldon, overlooking the lake of that name on the Ross river, is so formed.

The rock here is a granite porphyry, of exceedingly coarse grain, in the form of a pillar, which has eaten its way up through the Palæozoic sediments.

The contact is well defined; the granite has merely baked, and rendered brittle the argillites enclosing it.

The granite is well jointed, and weathers into a serrated crest, the argillites being worn away for a distance of several hundred feet below the summit.

As the granite stocks or pillars become unroofed they offer greater resistance to weathering than the mountains composed entirely of sedimentary rocks, hence the mountains possessing granite centres persist longer at high elevations, and are also more conspicuous by reason of their bolder outlines and more rugged crests.

Itsi mountain and Mount Wilson are of this character, and several

* R. G. McConnell. Ann. Rept. Geol. and Nat. Hist. Survey of Canada, Vol. IV, 1888-89, Part D, pp. 95-100.

mountains on the Macmillan and Stewart rivers, which are prominent topographic features, were found to be built of granite.

On the banks of the Ross river between Big Timber creek and the first rapid, are a few isolated exposures of granodiorite and rhyolite, both bedded and massive, but the relation of these bodies to the sedimentary rocks and to each other was not seen.

On Pelly river below Slate rapid are a few outcrops of diabase, intrusive in slates and quartzites. This rock is fine grained and much altered, is traversed by veinlets of quartz and calcite, and becomes slightly schistose at the margins.

Large boulders and blocks of similar rock were seen on the lower part of the Ross river, but were not found in place in that locality.

Igneous rocks appear to be almost absent on the Gravel river, the only occurrence observed being a sill of diabase intruded between beds of horizontal sandstone.

The diabase was first seen below the mouth of Twitya river, where it forms a cliff 100 feet high, about 3,000 feet above the river, on the mountain on both sides of the valley. Some miles farther on a fault brings the diabase down to the level of the river. It is coarse grained, and much decomposed, with a roughly columnar structure.

Superficial Deposits

The valley floors of the Pelly river and its tributaries are all covered with drift deposits of varying thickness. Most of this material appears to have been laid down by the complex action incident on the occupation of the region by glaciers.

A complete section of the drift shows rolled gravels at the bottom, then boulder clay, above which are sands and gravels, usually stratified, with silt on top. The deposits are very irregular, and their sequence varies in every section examined, it being frequently found that two layers of boulder-clay are separated by stratified sand and gravel.

The drift is usually thickest along the lower portion of the streams, where sections are generally seen rising to a height of 300 feet above the river, while older terraces of similar material rise to a height of 900 feet.

Although there are some detached thick heaps of drift material in the upper valleys, the drift sheet is usually thin, and boulder-clay is either altogether absent or else confined to patches of small extent.

Deposits of drift are found on the Ross river throughout the greater part of its course. The immediate banks are usually low, averaging about 15 feet, and only rising in a few places to 40 or 50 feet, but remains of older terraces of drift 100 feet or more in height occupy the base of the valley slopes. The boulder-clay member of the drift on the Ross river is dark in colour, not very coherent, and contains mostly fine pebbles, differing in many respects from that of the Pelly, which is yellow in colour, generally stiff and carries chiefly large pebbles. The gravel, clay and silt on the Ross river is stratified in fairly regular beds, and does not exhibit the confused arrangement so common on the Pelly and Macmillan rivers.

The wash gravel in the river bed is principally composed of small fragments of chert or argillite derived from the prevailing country rock, which crumbles down very fine, but in contrast to this fine material large angular or partly rounded blocks of granite and fine-grained greenish diabase are strewn at intervals over the bed of the river, or are perched on the banks.

A large deposit of unsorted drift material which contains a good percentage of rounded granite pebbles occurs on the river below Lewes lake, and terraces of the same material rise to a height of 300 feet above the present level of the lakes. The wide valley containing Prévost river intersects that of the Ross at this locality, and it is probable that during the shrinkage of the ice an overloaded glacial stream from both valleys discharged at this point, building up sufficient material to act as a dam and pond the water for some distance above.

Another extensive deposit of glacial material occupies the valley bottom about ten miles above Sheldon lake, of which bluish earthy clay, abounding in pebbles, is the chief component. In this the Ross river has sunk its channel to a depth of 450 feet, leaving two series of very perfect terraces which border the valley for several miles.

In the upper part of the valley of the Ross, the principal deposits of drift are in the form of esker ridges extending from the base of the slopes, the material composing these ridges being sand and gravel or boulders, with very little clay.

About the middle of Christie pass there are some mounds about 200 feet high composed of angular quartzite and fragments of slate from the surrounding mountains, also several rounded and sub-angular granite pebbles, but very little sand or fine material. Three of the mounds occupy isolated positions in the middle of the pass, while others are attached as benches to the northern side. They have a gently-rounded outline with flattened summits, and appear to be remnants of a large area of drift.

The Gravel river after leaving the divide flows in a shallow trench sunk in the rocky floor of a poorly developed valley.

No superficial deposits of any importance were observed above the mouth of Tsichu brook; below this point are a few sections of roughly stratified gravels about 100 feet in thickness.

This deposit is not of any great horizontal extent, as a bedrock bench 200 feet higher than the gravel bench rises a short distance beyond the latter. A few patches of typical yellowish boulder-clay, but showing peculiar lines of bedding, are found in this vicinity. Granite boulders of large size are very numerous; these litter the beds of the side streams, and are scattered over the valley slopes.

An important terrace of gravel about 200 feet high occupies the triangular space of a few miles in extent at the junction of the Natla with the Gravel river.

The terrace is composed of river gravels, with boulders and pebbles of sandstone, dolomite, limestone, and slate, but only a few small granite pebbles are present, and below this point granite is altogether absent from the river wash.

Where the banks of the stream are not of solid rock, they are generally composed of the above material, but mostly in low banks from 10 to 20 feet in height.

At several points, the river banks are the truncated alluvial cones brought down by the side streams, and these generally contain a large proportion of angular or only partly rounded fragments of rock.

Sections of a thin sheet of boulder-clay are seen at intervals. This material is generally stratified, and contains a layer of gravel and sand without admixture of clay.

Above the mouth of Nainlin brook, the river bank is composed of about 120 feet of dark blue clay, quite structureless, and containing a few pebbles, the larger of which have flattened and scratched surfaces. Most of the pebbles are small and well rounded, the greater part being of granite and gneiss of various character.

Granite pebbles are absent from the gravels for a distance of seventy miles above this point, and they were evidently carried up the valley of the Gravel river by glaciation from the east, the pebbles being typical of the rocks of the great Laurentian area.

On the opposite shore below this point are banks of the usual Gravel River boulder-clay about 80 feet high, showing bands of gravel and silt. The boulder-clays from the two sources show marked differences in colour, composition and structure.

Below this point the granite pebbles in the wash increase in size and number, but are not found up the side streams above a level of about 200 feet higher than the main river.

The thickest deposit of drift on the river occurs about eight miles below the mouth of Inlin brook, where the river turns eastward through the foothills.

The base of this section shows typical boulder-clay, above which are bedded silts, and above the silts is another deposit of boulder-clay; on top is a bed of earthy non-coherent clay containing only a few pebbles. All these materials are of a dark-grey muddy colour, and have a total thickness of about 500 feet.

The broken plain bordering the Mackenzie is underlain by blue clay with a more or less gravelly admixture, on top of which is yellowish sand or sandy gravel. The gravels contain a large proportion of black chert or slate pebbles derived from the underlying Cretaceous conglomerate.

About four miles from the Mackenzie the Gravel river swings against a clay bank about 200 feet in height, and of a dark-grey colour. The lower part of this clay is stratified, and appears to be quite devoid of pebbles, but the upper 50 feet or so contain scattered pebbles.

The river is undermining this bank, and at intervals large masses of clay, becoming detached from the face, fall with a roaring noise into the swift water.

Glaciation

It would appear that during the glacial epoch a thick deposit of ice accumulated among the mountains, the gathering ground being on the western slopes.

This ice sheet, judging from the height at which foreign material was found on the mountains, was about 3,000 feet in thickness, and although it did not cover the highest peaks was thick enough to override the lower mountains and ridges, so that the glacier was a confluent one over the region and also the northern extension of the great Cordilleran glacier.

The movement of the ice during its maximum development was controlled to a great extent by the main drainage valleys, and flowed down those almost, but not quite, to the Yukon river.

When the ice became thick enough on the western slopes of the Mackenzie mountains it began to pour through the gaps and passes of the divide and to send streams down the valleys of the Gravel river and its branches.

The ice divide appears to have been situated at one period of the glaciation to the west of the present watershed, because granite drift was carried from the western side part of the way down the eastern slopes, but it is probable that on the shrinkage of the glacier the ice divide shifted to the present watershed, as the accumulation of drift in Christie pass appears to have been deposited at a zone of stagnation, or where there was no movement of the ice.

The depth which the ice of the Cordilleran glacier attained in the valley of the Gravel river was not satisfactorily determined, the effects of glaciation not being so pronounced as on the Pelly and its tributaries. It is probable, however, that there was a depth of at least 2,000 feet on the lower part of the river.

The valley of the Mackenzie river was occupied by an ice sheet of considerable thickness, which pushed up the valley of the Gravel river, before the ice from the Cordilleran glacier began to pour down.

A large boulder of gneiss was seen at the mouth of Nidhe brook, at a height of 1,800 feet above the Mackenzie river, showing that the two ice sheets merged somewhere in that vicinity. The drift pushed up by the Mackenzie glacier is mostly all cut away by the present stream for a long distance below that point, and the first large accumulation occurs above the mouth of Nainlin brook, thirty miles below the mouth of Twitya river.

According to McConnell's* observations, the ice from the gathering ground on the Archæan area to the east, poured westward through the gaps and passes in the Franklin range, and, flooding the Mackenzie valley, was deflected northward by the great barrier formed by the Mackenzie mountains, in a stream approximating 1,500 feet in depth.

Camsell** noted water-worn pebbles and boulders of gneiss on the summit of Mount Goodenough, a mountain built of Cretaceous strata, about 3,000 feet high, overlooking the delta of the Mackenzie.

According to these later observations then, ice from two gathering grounds, an eastern and a western one, combined in the Mackenzie valley, and the maximum thickness of this ice must have been considerably over 3,000 feet.

It is probable that local glaciers remained in some of the higher mountain groups after the general disappearance of ice from the field. The only permanent ice of any account now remaining in the region is confined to a few small patches about a square mile in extent, in the cirques of the Itsi mountains, which lie between the Ross and Macmillan rivers.

Economic Geology

Prospecting for gold began on the Pelly river as early as 1882. For some years subsequently, a few miners working on the gravel bars made as much as $10 to $20 a day each, their operations being confined to the lower portion of the river. Since then prospecting has been carried on along the greater part of the river and many of its tributaries; but no mining of importance has yet been done in the region.

Fine and coarse colours of gold are found in the gravels over a large area, but no coarse gold in paying quantities has yet been located on bedrock.

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* R. G. McConnell. Ann. Rept. Geol. and Nat. Hist. Survey of Canada, Vol. IV., 1888-89, Part D, p. 27.

** C. Camsell. "Peel River and tributaries", Geol. Surv., Canada, 1906, p. 40.

There appears to be a close connexion in the Yukon territory between the crystalline schists and the placer deposits. In the valley of the Pelly, these rocks appear to occupy a belt extending for a distance of about ten miles on each side of the river, which flows generally parallel to their strike. In the vicinity of Campbell creek, however, the Pelly river turns northeastward, while the belt of crystalline schists continues in a southeasterly direction along the Frances and upper Liard rivers.

In 1875, some prospectors from the Cassiar gold fields, in search of new grounds, reached the headwaters of Frances river, and worked on some bars, obtaining gold which paid at the rate of $8 to $9 a day, and there is no doubt that the Yukon gold fields would have been entered and discovered at that time from this quarter, if the route were an easier one, and not so remote from any base of supplies.

For the last few years work in the Pelly district has been confined to the streams entering the Pelly from the south, from and including Lapie river to Hoole river.

These streams head in the Pelly mountains, a high range, lying south of and parallel to the course of the Pelly. Along the base of these mountains lies a wide abandoned river valley, floored with wash gravels and containing several small lakes. This old valley is separated from the Pelly river by a narrow belt of low rocky hills, through which the streams have cut channels. The gravels of the old valley carry coarse and fine colours of gold, and the streams in flowing across it concentrate a portion of this gold on bedrock.

The best prospects so far have been found on some of the small tributaries of Hoole river.

The Duncan mining district, to the north of the Pelly, resembles the country in the vicinity of the latter in many respects. Coarse gold in paying quantities was found in that region about ten years ago, and almost every year since then discoveries of more or less importance have been made. In spite of the large area over which gold has been found in the Duncan country, there are serious difficulties hard to overcome, which prevent it from becoming a successful mining camp. These are: underground water, large boulders, and lack of adequate transportation to ensure a supply of provisions for miners.

Fine gold is found in the gravels all along the Pelly, from the Yukon to Campbell creek, but none is found above this point.

Mr. Henderson tested a few bars above Hoole cañon, using two sluice-boxes, about 12 feet long, and collected several pounds of the heavy dark sand which accompanied the gold. A greyish-white, malleable mineral in small scales, which was presumed to be platinum, is abundant in this sand.

The samples were submitted to Mr. R. A. A. Johnston, mineralogist to the Geological Survey, who states it to be ferro-nickel, a rare mineral, but of no commercial value in such small quantities. The bulk of the black sand is composed of magnetite and garnet.

The bars that produce best on the upper Pelly, begin about a mile below Hoole cañon and extend up stream for about sixteen miles.

The surface gravels to about a foot in depth yield approximately $2\frac{1}{2}$ cents to the pan, and $1\frac{1}{2}$ cents at two feet below the surface. The boulders are not large and the gravels are not frozen.

A few years ago three men rocked on the bars above Hoole cañon, and made about $2.50 per day each. The gold is very fine and hard to save, but

Mr. Henderson says that with better appliances for washing the gravel, and saving the gold, it is possible to make from \$5 to \$6 per day.

Veins and stringers of quartz, which are probably due to the after-effects of igneous intrusions, are abundant in the crystalline schists. The occurrence of gold was not traced directly to the quartz seams in this locality, but the gold in deposits of economic importance has been limited to those areas in which the rocks are highly altered, and disturbed by frequent intrusions.

During the glacial period part of the ice which filled the Pelly valley came from the southeast, and moving over a large area of schists and slates, transported some of the pre-glacial accumulation of gold from these rocks. It is probable that the gold in the bars of the main river is derived from the glacial drift. The river does a certain amount of cutting into these deposits at every flood stage; the gold scattered through the drift is fine enough to be carried in the turbid water. The concentrations of gold are generally restricted to small areas at the head of each bar, and on account of their shallowness and small extent, diggings of this nature are soon exhausted.

The mineralization of the schists by the igneous intrusions was not confined to the deposition of gold, as in other localities various minerals of more or less importance are found associated with coarse gold on bedrock. These minerals are cassiterite (oxide of tin), scheelite (calcium tungstate), bismuth, stibnite (antimony sulphide), zinc blende, arsenical pyrites and iron pyrites.

Although these minerals have not been reported from the Pelly region, it is possible that they occur there, and on account of their heaviness are likely to be found concentrated in sluice-boxes.

Under present conditions, however, it is unlikely that anything but gold, which is by far the most valuable mineral known to occur there, will be sought for.

From the superficial examination given to the country in the vicinity of the Ross and Gravel rivers, it appears to be a most unattractive one to the prospector or miner.

There is a marked absence of vein quartz either in the bedrock or stream gravels along the route. The intrusion of the granites in the sedimentary rocks does not appear to have been accompanied by any mineralization. The excess of silica usually accompanying granite intrusions appears to have permeated the argillites in an amorphous form, altering them to cherts. The silicification of the bedded rocks is on a large scale, as there are several thousand feet of chert beds extending over a large area.

An assay was made of a specimen from the bed of quartz conglomerate which crosses the Ross river at Prévost cañon, but no trace of gold was found.

At least two parties of miners have prospected in late years on the Ross river, but without success. Chas. Wilson, who has prospected on the upper portion of the river for the last three years, informed me that he only got colours of gold in one small stream flowing into the Macmillan river, and that he found no coarse gold at all.

The explanation of Wilson's persistence in remaining in an apparently barren field is that he is in search of the legendary McHenry mine, a phenomenally rich deposit of placer gold supposed to exist in this vicinity. McHenry is said to have been a miner from the Dease Lake diggings, who penetrated to this region on a prospecting trip many years ago, and took out forty pounds in weight of coarse gold and nuggets. Various reasons were given for not returning again to his Eldorado, but he gave certain approximate directions by which it might be located, and many prospectors have been beguiled into the quest. A great deal of the country between the Macmillan and the headwaters of the Nahanni has been traversed in search of this lost mine.

Quantities of drift lignite are found along the lower part of Campbell creek, but the seams from which it was derived were not found. There is probably a small Cretaceous area lying on the schists in this neighbourhood similar to the one at Five Fingers on the Yukon river.

Drift lignite is also found on the lower part of the Gravel river, which is no doubt derived from the Tertiary coal-bearing areas of the Mackenzie basin.

Hematite occurs on the Gravel river about ten miles below the mouth of Natla river. This iron ore is coarsely laminated with red siliceous slate, having a thickness of from 50 to 100 feet, and is interbedded between conglomerate and dolomite. An assay of an average sample of this ore was made at the assay office of the Mines Branch, and gave only 25 per cent of iron.

1909

Introductory Note

In 1909, the Director, Mr. R. W. Brock, includes the following note in his Summary Report for that year (pages 2, 3) on field work in Yukon:

"Mr. D. D. Cairnes spent the season on the Wheaton River, near Whitehorse, Yukon Territory. He discovered some coal seams in this district which may prove important. The district is extensively mineralized. Mr. Cairnes also visited certain quartz veins east of Whitehorse, and some copper deposits recently found on Williams and Merrice Creeks near Yukon Crossing."

In the late summer of 1909 Mr. Brock visited Yukon territory, and the following first report was compiled from notes taken by him at that time. The succeeding report, on the Wheaton River district, is by D. D. Cairnes for the same year.

YUKON TERRITORY

by R. W. Brock

Carcross

The most serious attempts to establish lode mining in this northern section of the Dominion are the operations near Carcross, in what has been termed the Conrad district. A recent report by Mr. D. D. Cairnes* describes the district and its ores in detail.

In the time at our disposal, we were able to visit only the Venus and adjoining claims on Windy Arm. A small concentrator has been built on the lake shore, connected with the mine, 900 feet above it, by an aerial tram. About 3,000 feet of development work has been done, consisting principally of a cross-cut tunnel of 600 feet to the vein, and drifts on the vein 500 feet long on each side of the cross-cut. At the ends of the drift are winzes, 150 and 180 feet deep respectively. There is also a raise to the surface. The vein, which is very persistent, varies from $1\frac{1}{2}$ to 4 or 5 feet in width. It is oxidized for about 350 feet below the surface. The oxidized ore is said to run about $10 in gold and $10 in silver. Below the zone of oxidization the gold value is reported to be higher. The vein, angling down toward the lake, may be traced on the surface westward for several claims. An aerial tram connects the Vault to the lake, and another connects the Montana with Conrad. Other claims on which considerable work has been done are the Thistle, Aurora, and Pelly. The Venus and adjoining claims were being operated at the time of our visit.

The chief interest at present in this section centres in the developments at the Big Thing, about five miles from Carcross. I was not able to get out to this property. The vein is said to run from 5 to 16 feet in width, and to carry a quartz-arsenical-gold ore of good grade. A shaft has been sunk at an angle of about 45°, to a reported depth of about 610 feet. It is said to be the intention to tap the vein by a cross-cut tunnel, from the mouth of which an aerial tram will carry the ore to the railway.

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* "Report on the Conrad District", by D. D. Cairnes, Geological Survey, No. 982.

Whitehorse

A day was spent at Whitehorse visiting the copper claims in the vicinity. These deposits are of the contact metamorphic type, like the Boundary Creek and Texada Island deposits. They have been described by Mr. R. G. McConnell in a recently published report*.

Concerning the three best developed iron ore bodies, Mr. McConnell estimates the tonnages that may be considered assured as follows:

Pueblo

"The Pueblo ore body consists of an impure mass of hematite, 300 feet in length, with a maximum width of 170 feet. The surface section measures approximately 33,000 square feet. The ore body has been proven to a depth of 100 feet, and at 70 feet a drift of 120 feet failed to cross the lode.

"Assuming that the ore body carries its surface size down to the bottom of the shaft, it would contain 3,300,000 cubic feet of ore above that level. The weight per cubic foot is not definitely known, as the hematite is intermixed with various impurities such as garnet, epidote, quartz, calcite, etc.; but probably averages about 8 cubic feet per ton. This would give a tonnage of 412,500 above the 100-foot level. It is probable that the lode extends some distance below the 100-foot level, and a considerable additional tonnage might safely be added.

"Copper contents probably average 3 per cent. Gold and silver values are small, about $1."

Best Chance

"The ore body is a mass of magnetite, 360 feet long with a maximum width of 65 feet. The surface section measures approximately 13,120 square feet.

"The workings are shallow, and have not proved the deposit to a greater depth than 35 feet. In addition to this the lode projects 15 to 20 feet above the surface. A total depth of 50 feet represents the proved portion of the lode at present. With a depth of 50 feet the lode contains 656,000 cubic feet of magnetite, weighing, at 8 feet per ton, 82,000 tons.

"The grade of the ore in copper is about 3 per cent. The gold and silver values are small.

"The probable tonnage is at least double of that given."

Arctic Chief

"The Arctic Chief ore body on the main level, 65 feet below the surface, has a length of 190 feet and an average width of 30 feet, the section measuring 5,700 square feet. A shaft from the main level proved ore for a further distance of 25 feet, or a total distance of 90 feet. The surface section is on a slope, and part of the ore body has been removed by erosion. Assuming 80 feet as the average depth of the lode, the contents measure 456,000 cubic feet, weighing, at 8 feet to the ton, 57,000 tons.

"Average copper contents	4 per cent.
Average gold	$4 per ton.
Average silver	2 ozs. per ton.

"Numerous smaller iron masses and irregular lenses of bornite-chalcopyrite-ore occur throughout the district."

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* Report on Whitehorse Copper Belt, Geol. Survey, Pub. No. 1050.

It is likely that the ore on the Pueblo will extend below the present workings at least 50 feet, so that 250,000 tons might be considered as probable ore for the Pueblo. This would give over 800,000 tons on these three properties alone. But the ore may extend for a considerable distance below the present shallow workings. The experience elsewhere on deposits of this type has usually been that considerably more ore is recovered than has been estimated from limited development work. These deposits, therefore, appear to be already capable of producing an important tonnage, with promising prospects for future developments.

None of these properties were working at the time of our visit. It is reported that a spur from the railway will be completed to the Pueblo in the spring, and that shipments may then be made. Some prospecting was being carried on in the Wheaton River district a few miles to the south of Whitehorse. Low grade copper ores similar to the Whitehorse deposits were found this year at Williams creek, near Yukon Crossing. Concerning these Wheaton River and the Williams Creek prospects, information will be found on a later page in the summary report of Mr. D. D. Cairnes. The Wheaton River district contains silver, lead, gold, and antimony veins of some promise. Mineralization is widespread. Coal similar to that at Whitehorse and Tantalus was found this summer by Mr. Cairnes on Bush mountain. The Tantalus coal mine is producing.

Klondike

Dawson was reached on the night of August 19. The first day was spent in Dawson itself. On August 21, I went 10 miles down the river to see a rock bluff on the east bank which was reported to pan gold. In the afternoon the party visited the dredge operated by Mr. Simpson on Bonanza creek. On August 23, we started to visit the creeks, accompanied by Mr. F. T. Congdon, M.P., and Commissioner Henderson. Mr. Gray, of Dawson, was with the party for a couple of days, and Sheriff Eilbeck for the rest of the time. The district is well supplied with good roads, so that an automobile was used throughout.

We first went up Hunker creek and down Dominion creek to 33 Below, stopping at Peter Rost's, where we witnessed a clean-up. A pan of fine nuggets from new ground on Caribou creek served as an interesting reminder that discoveries of rich ground can still be made. Returning to the summit, the night was spent at the roadhouse. Next morning a stop was made below the Dome to visit the tunnel being run in from Dominion Creek slope, to prospect quartz veins that have been located on the surface. From the tunnel we proceeded to Sulphur creek, and down Sulphur to Granville, where we spent the night. On the 25th we returned to Sulphur, and down Hunker to Dawson. Next day, Bonanza, Eldorado, and Quartz creeks were visited. The night was spent at Quartz, and the following day we proceeded up Quartz to the Dome and down Bonanza to Dawson. The following day I accompanied Mr. A. N. C. Treadgold to Hunker and Last Chance creeks, and spent the day on the White Channel gravels. On August 29, Mr. Templeman left Dawson for Victoria via Skagway, while I continued down the Yukon, to visit the placer camps of the lower Yukon and Seward peninsula, returning to Victoria via Nome.

Present Conditions

Gold mining in the Klondike is rapidly changing in character. Individual mining is being superseded by large scale operations, with such engineering and mechanical aids as water, led in from a distance, electrical power, mechanical lifts, dredges, etc. The Yukon Gold Company is working on the largest scale, and is about to increase its effective operations. The Yukon ditch has been completed from Twelvemile to Gold hill, a distance of about 70 miles. In its course across country it is alternately ditch, flume, and pipe (the latter as a huge inverted syphon in crossing valleys such as the Klondike). Hillside springs and marshes present difficulties in maintaining the ditch, but it is rapidly becoming 'seasoned' by skillfully applied natural means, and, it is hoped, will soon have the stability of a natural water-course.

Seven dredges are being operated successfully by this Company and three mechanical lifts. These plants are operated by electricity furnished by the Company's power plant near Little Twelvemile. The main, high-voltage transmission line is 36 miles long, besides which there are 18 miles of branch lines and 8 of secondary lines. In all, ten dredges are working in the Klondike, three on the river itself, five on Bonanza creek and two on Hunker creek.

A very extensive scheme for power development is under way on the Klondike river about 30 miles above Dawson. Water from the North Fork of the Klondike will be utilized to generate power to be transmitted over all the mining district. Individual claims are being rapidly consolidated, usually by purchase, into larger holdings. With a greatly increased number of plants, it will still take years to clean up the gravels of the district. Practically all the worked-over ground and underlying bedrock will be re-treated by mechanical devices. High-level gravels for which there was no available water, and claims which by reason of mechanical difficulties could not be attacked by the individual miner, will furnish a big additional field for large-scale operation. McConnell, in 1906*, estimated future production at about $63,000,000, making no allowance for rich discoveries. The work done since then is said to have shown that this estimate was thoroughly conservative, and that the actual production will be considerably in excess of these figures.

Some attention is being directed to the quartz possibilities of the Klondike, and many claims have been staked. The neighbourhood of the Dome, Goldbottom creek, and Victoria gulch are the localities so far in most favour, but interest is not confined to these. Little work, however, has been done, and no decisive data have yet been obtained.

On the Dome property a tunnel is being driven into the hill from the Dominion Creek slope, with the intention of prospecting several quartz veins which it is expected will be cross-cut between 950 and 2,000 feet. The prospect is equipped with a small compressor plant, and at the time of our visit the tunnel was in 920 feet. For the first 150 feet the ground is frozen; inside the frost line, the rock is solid Klondike schist. A few slips occur and small quartz veins, also bunches of quartz and calcite. Most of the slips and veins dip into the hill, but a few with it. The movement along the slips appears to have been small. In one instance a slip faulted a 2-inch quartz vein, causing a displacement of about a foot and a half. These small veins

* Gold Values in the Klondike High Level Gravels, Geol. Survey, Pub. No. 979.

give the impression of being persistent. The slips are not very numerous, and the ground inside the frost line is as solid and free from disturbances as in most mineralized areas. Near the surface, in the frost zone, the ground is broken into small blocks which are gradually working downhill. This 'creep' is quite pronounced. Since our visit, it is reported that two ledges have been encountered from which good assays have been obtained.

Near the close of the season, a two-stamp mill on the Lone Star group at the head of Victoria gulch made a test run of over one hundred hours on surface quartz, with results that are said to be entirely satisfactory. McConnell, in his report on the Klondike Gold Fields (p. 65), speaking of these veins says, "the prospects are certainly encouraging, and warrant further investigation".

The prospecting on the rock bluff 10 miles below Dawson, and below the Indian village of Moose-hide, shows that attention is not wholly confined to the placer creeks. The bluff consists of coarse, quartz-mica schists, with numerous quartz stringers, a few of which are said to pan gold. But the rock which attracted attention is a basic igneous dike which cuts the schists. On the exposed surface it is rusty-weathering with a marked spheroidal structure. We did not succeed in obtaining colours, but subsequent pannings are reported to have yielded positive results.

As yet there is nothing definite on which to base a judgment regarding the quartz possibilities, but there are facts in connexion with the geology of the district and the occurrence of placer gold, which have a bearing on the question, and furnish at least suggestions with regard to prospecting for quartz. Detailed descriptions of the district may be found in McConnell's Klondike Gold Fields (Geological Survey, No. 884), and his 'Gold Values in the Klondike High Level Gravels' (Geological Survey, No. 979), and need not be repeated here. But the salient points which strike the visitor may be worth mentioning.

Geological History of the Klondike

The complete geological history of the district is, of course, somewhat more complicated than represented in the following notes. The district is not glaciated, and the present topography is the result of weathering and erosion. Viewed from an eminence, the streams are seen to possess wide valleys with gently sloping sides rising to rounded hills with broad, rather flat tops. Outcropping rocks are conspicuously absent. Broad amphitheatres at the heads of the creeks are characteristic. Rock-waste subdues the outlines of the hills, and deep gravel deposits cover the gently sloping valley bottoms. Here is seen a region in a state of advanced maturity. But rejuvenescence occasioned by a recent uplift is also observable. The Yukon has sawn a trench 700 feet or so into the bottom of the old valley. The Klondike, responding to this lowered base-level, has correspondingly trenched its old bed, and Bonanza and Hunker creeks have channelled their valleys in harmony with the new Klondike level. The creeks south of the Dome are still in the old channels, for the Indian river has not yet advanced its new cañon as far up as the mouths of these streams.

For a period extending a long distance into the geological past, conditions of weathering, erosion, and deposition have obtained, with no disturbances sufficient to seriously interrupt these processes, to erase their effects or sweep away their products. This fact, brought into notice by the topography of the district, is accentuated by an examination of the gravels themselves. The old valleys, except where covered by recent accumulations or cut into by the rejuvenated streams, are floored with 'White Channel gravels', which rest on a yellowish, clay-like bedrock, the weathered, rotted country rock. The 'White Channel gravels' themselves are bleached mixtures, consisting largely of fine sericite and quartz pebbles. Pebbles of country rock have decomposed and fallen to pieces, or if present, disintegrate at a touch. Stratification is gone. Decomposable minerals have broken down. Soluble elements have been leached out, and stable combinations like sericite formed of what remains. Magnetite is practically absent, though originally it must have been plentiful. Only the most resistant minerals, such as quartz and sericite, with some gold, are left. Weathering, therefore, has been an important and long-continued process on the rock surfaces, in the hillside wash, and, finally, in the stream accumulations in the valley bottoms.

The country rock consists of sericite and chloritic schists, with some dark, graphitic argillites cut by some dikes of igneous rocks, quartz porphyries, rhyolites, and andesites. Quartz veins and stringers, some, at least, gold-bearing, are abundant in these schists. Exposures are not numerous, being largely confined to occasional outcrops on the summits or in the cañons of the rejuvenated streams. But the large amount of quartz in the debris which mantles the solid rock evidences the presence of quartz veins where they are not exposed.

The old White Channel gravels, representing a natural concentrate from a great mass of gold-bearing material through long ages, by weathering and stream action, are rich in gold. The gold occurs in a well defined paystreak, as is usually the case in stream gravels. The present stream beds where they have cut down through the White Channel paystreak were enormously rich, as might be expected since they represent a reconcentration of an already rich concentrate. Where the White Channel paystreak was untouched, the present stream bed was apt to prove lean. Going up stream, the gold usually becomes less worn, rougher, more angular, and coarser. The gravels are not always of pay grade to the heads of the creeks nor always to the mouths of the creeks; some of the tributary gulches are rich and some have proved barren. Often gulches which head together are paired as to gold contents. If one is rich the other is rich; if one is poor the other is poor. Gold in the recent gravel freshly derived from its original source is similar to gold in the corresponding White Channel gravel. Many of the gold grains and most of the nuggets, enclose quartz. Quartz pebbles are found containing gold, some at least very rich in gold. The quartz of the boulders is similar to the quartz of the veins, and gold of the veins to the gold of the gravels. From the foregoing and other facts, it is obvious that the gold is absolutely local in origin, derived from the basins of the pay gulches and creeks.

Quartz Possibilities

The extraordinarily rich gravel represents the concentration of a great mass of gold-bearing material. There are several possibilities regarding the source of the gold. It might be derived from disseminations through the country rock. A gold value of a few cents a ton, such is the volume of country rock weathered and eroded, would more than account for all the millions in the gravels. But this interpretation does not fit the facts. In addition to those above alluded to, it may be recalled that Eureka creek, which is gold-bearing, is not in the Klondike schists at all, but in the Nasina series, which almost everywhere else is unproductive. It is then practically certain that the gold of the gravels has come from the quartz veins. When one considers the extremely local occurrence of the gold, the suggestive form of the nuggets, the overwhelming importance of quartz in the gravel, the widespread occurrence of quartz in the very nuggets themselves, the 'kindly' appearance of the quartz of the pebbles and the actual occurrence of gold in this quartz and also in some of the veins so far uncovered, the numerous veins on the rich creeks, etc., no other view seems at all tenable. But granting this, there still remain several possibilities. The gold may be somewhat uniformly distributed throughout the innumerable quartz stringers and veins, in which case they would almost certainly be too lean for profitable exploitation. The probabilities, however, are that this is not the case, and such facts as are known do not suggest this possibility. To begin with, this is not the usual characteristic of gold-quartz veins. Again, quartz is widespread; gold confined to particular creeks and gulches. Some of the quartz boulders are likely-looking, some very unpromising; suggesting that they are from veins of different origin and contents. Other facts also tend to indicate that the gold is confined to certain veins. The large nuggets and the richness of the gravels at the heads of some of the pay channels would suggest that in the auriferous veins themselves the gold is already concentrated to a certain extent at least. The rich kidney of quartz found on the New Bonanza claim, Victoria gulch, is an example.

Up to this point, the argument is all in favour of the possibilities of rich quartz veins, but here some uncertainties enter. The gold might be concentrated in ore shoots, as is usually the case in veins. These might be large and workable bonanzas or small and pockety. The pay ore may have been largely removed by erosion, and for the most part, only low-grade roots of veins left. Veins, though rich, might be too small or irregular for mining. McConnell admits that most of the veins seen by him were of this character. On the other hand, comparatively few of the veins have been exposed, and it is quite possible that large and regular veins are to be found. So far, developments on the Dome property tend to strengthen this possibility. Moreover, the small veins might occur in groups or zones that collectively might be capable of development, or the country rock in the neighbourhood of a vein might prove sufficiently mineralized to give workable dimensions to the ore body. There is not yet sufficient information available to determine the actual conditions in the Klondike with respect to these last points, so that the future of the lode mining cannot be predicted with certainty. As just shown, the balance of the evidence, so far as it goes, is distinctly favourable, and the stakes are tempting. In my opinion, then, it is well worth while making serious attempts to locate workable quartz.

In this connexion it is interesting to note that prospecting for quartz in the placer camps of Alaska is furnishing encouraging results. Some promising gold-quartz has been found in the Koyukuk and Chandalar regions. At Fairbanks, according to information furnished by A. H. Brooks, of the United States Geological Survey, prospecting for quartz or veins has been carried on at a number of points. Veins varying from less than an inch wide to 12 feet have been found. The rich ore has thus far been confined to stringers or veins under 3 feet thick, but valuable material is reported in places in the adjoining country rock. Though many of the individual stringers pinch out and some of the veins are faulted, others may be followed for several hundred feet. Development work is as yet limited, but the prospects are considered sufficiently encouraging to warrant serious development and further prospecting for quartz veins.

On the Seward peninsula, quartz seems to be receiving greater attention than ever before. This autumn a magazine was started at Nome in the interests of quartz mining on the peninsula. The Big Hurrah mine, in the Solomon River region, has been operated for a number of years, and has the distinction of being the first lode mine on the peninsula. It has a stamp mill, and seems to have demonstrated that in certain spots at least, mineralization is sufficiently concentrated, and veins sufficiently large and continuous, to make a lode mine. Here is one place where a northern placer has developed into a lode mine, and where some of the placer gold has been traced to its source.

Notes for Prospectors

The prospects for developing lode mines in the Klondike I would consider to be quite as promising as in the lower Yukon. The most attractive prospecting ground is naturally on the creeks which have had rich gravels, for since the gold is local in origin and, presumably, derived from quartz, they indicate the existence of auriferous veins in their basins. Some guidance as to the best points to prospect in the individual basin is furnished by the gold in the gravel. For example, the head of a creek or a tributary gulch that has a bedrock which would retain gold, but does not contain pay gravel, would be an unpromising field for prospecting. On the other hand, the valley walls or the gulches at the head of pay gravel would be likely ground. For instance, Victoria gulch with No. 7 pup is almost at the head of the productive part of Bonanza creek. The gold is coarse, and in the upper part very rough and angular. Here, evidently, one is 'hot on the scent'. On No. 7 pup the gravel is angular, and consists of almost unworn slide rock. This should be a good place to prospect. Gay gulch, which heads with Victoria gulch, is also auriferous. This and the divide between the two gulches furnish favourable ground. A study of the geological maps and reports, and a consideration of the production from the various claims, will furnish numerous suggestions regarding other good points for attack.

When the gravels of a creek appear to be enriched on a certain claim as if from a local source of gold, it should first be determined if the excess supply has been derived from the White Channel paystreak. Only when this has not been the case may such enrichment be taken to indicate the presence of a rich vein in the immediate vicinity. If coarse or unworn gold suddenly makes its appearance where normally only fine and worn gold might be expected, this would be indicative of a fresh, local supply from a nearby source. Such would be a favourable place to prospect.

Prospecting will be slow and tedious, hampered as it is by the lack of rock exposures and the mantle of loose rock. The latter is steadily creeping down hill, a point to be remembered when float is discovered. When a vein is found and sufficiently uncovered to show the character of the vein material unmixed with 'wash', unless it is of pay grade it is usually unwise to sink on it or otherwise test it at depth in the hope that values will improve. If it is felt to be worth further development, it is usually better to prospect it horizontally rather than vertically. This can be done either by trenching, or if the cover is too deep, by drifting. Either will be cheaper and more rapid than sinking, and will test the vein as successfully, for the chance of striking better grade material along the vein is quite as strong as, if not stronger than down it, and much more of the vein is tested in the same time and for the same money. If, however, pay ore is encountered, it is advisable to sink on the ore as well as to follow the vein horizontally, for gold often exhibits a tendency to concentrate on the surface, and it is, therefore, necessary to demonstrate that the values continue downward. Until the ore shoot is well developed, so that certain knowledge is to be had of its position, dip, continuity, value, etc., in no case should expensive work be undertaken elsewhere than on the ore, under the assumption that it goes down, or has any particular attitude. 'Stick to the ore' is advice to be heeded. These points may seem too elementary to be worth making, but justification is furnished by the amount of money wasted in young camps, everywhere, by disregarding them, and by the frequent expenditure of time and money in a way that detracts from rather than adds to the value of the claim.

For the encouragement of prospectors it may be noted that, up to a certain point, the greater the number of veins that prove barren or almost so, the greater are the chances that some occur that are rich, for the reason that the fewer sources there are for the gold, the richer these sources must be.

Some light on the value of the quartz of veins might possibly be had from the quartz boulders of the gravels. Many will no doubt be from barren veins; many are cavernous. These probably held auriferous sulphide minerals which have been leached and the accompanying gold dropped out, in which case the values found would be too low. But tests made with discrimination and judgment might furnish some instructive results.

Placer Prospects

It is to many a matter of surprise that the discovery of the Klondike has not been followed by that of other important placers in the Yukon. The possibility of this is not yet exhausted. Prospectors from the Stewart are bringing out encouraging reports of creeks, tributary to this river. In some respects the conditions are very favourable for placer mining. From information which appears to be reliable, the placer prospects of the Stewart River district are to be taken seriously. Two dredges are being operated on the river.

Information obtained from the Klondike may be used with advantage in prospecting for new placers. Here, as noted above, the essential points were, gold-bearing country rock (auriferous by reason of gold-bearing veins), a very long period of concentration of the gold through weathering and erosion with, in places, a reconcentration of the already rich gravels. The same conditions were essential in the formation of the placer camps of the lower Yukon—notably at Fairbanks and the Seward peninsula. (At Nome reconcentration was effected on several beach lines.)

The presence or absence of the essential factors in a district, except the auriferous character of the country rock, can be speedily recognized by an inspection of its topographical features and the condition of the surface and of the old gravels. Whether the country rock is gold-bearing, and so could have supplied gold to the gravels, is not so readily determined, but in certain cases, at least, this can be more readily ascertained (or at all events its probability indicated) by an examination of the materials of the gravels, the slide rock, and outcrops than by the more laborious digging and washing of the gravels.

For instance, in the Klondike, the amount of quartz, and particularly the suggestive character of the quartz in the numerous milky, cavernous boulders, would indicate a strong probability of the occurrence of gold, which, coupled with the pronounced evidences of mature weathering and erosion, and reconcentration, would have attracted the observant prospector and encouraged him to expend the necessary time and labour to thoroughly test the gravels.

If these underlying principles regarding the formation of placers are borne in mind, it will assist one in eliminating unpromising districts and in confining his attention to creeks where there are inherent possibilities for success.

Other Districts

Placer mining is still in progress on tributaries of Sixtymile and on Fortymile rivers. Dredging is in progress on the latter.

The Sourdough coal mine below Fortymile river is in operation.

White River District

The encouraging developments of the copper properties on Copper river, Alaska, to which a railway from the port of Cordora is being built, and the similar prospects on the north side of the Wrangell mountains in the Nabesna-White River district, has re-awakened interest in the possibilities of the upper portion of the White river on the Yukon side of the International Boundary line.

In 1905, McConnell made a reconnaissance survey of this district, his report being published in the Summary Report of the Geological Survey for 1905 (pages 19-26). In 1907, very fine specimens of rich bornite and chalcocite were brought out from this district.

In 1908, Messrs. Moffit and Knopf of the United States Geological Survey, examined the Nabesna-White River district, Alaska. Portions of their report of special interest to Canadians, because referring to the Yukon, are here reproduced:

Mineral Resources of Alaska, 1908

(*An excerpt from United States Geological Survey Bulletin 379, 1908*)

Copper

General Conditions of Occurrence

The reported presence of native copper in vast quantities was, as already pointed out, the original incentive that drew the pioneer to the White-Nabesna region. Prospecting in search of these deposits has shown that copper in its bedrock sources is widely distributed in the form of sulphides (chalcocite, bornite, and chalcopyrite), and on the basis of the facts revealed by the little development work that has been done, it may be stated that most of the native copper found in the region is an oxidation product of those sulphides. In mode of occurrence the copper ore shows two different habits, geologically distinct. In one, so far the better known, it occurs associated with the Carboniferous basaltic amygdaloids, and in the other it is found in limestone at or near the contact with the dioritic intrusives.

Native copper occurs as nuggets in the gravels of many of the streams, and green-coated lumps of metal up to 5 pounds or more in weight are occasionally found in the wash of creeks draining areas of amygdaloid bedrock. This stream copper was the source from which the Indians obtained their supply when it was an object of barter among them. From the accounts of Hayes and Brooks, Kletsan creek appears to have been the placer locality best known to the natives.

Metallic copper occurs also in the surface croppings of sulphide deposits in the amygdaloids, where it is undoubtedly an oxidation product of the sulphides that appear in depth. In such places it is directly associated with the dark-red oxide (cuprite) and more or less green carbonate. At the prospect known as 'Discovery', which is located in Canadian territory on White river, a few miles below the International Boundary, a large slab of native copper averaging 8 by 4 feet by 4 inches thick, and weighing probably close to 6,000 pounds, has been uncovered in the slide rock. A number of other sheets of copper up to several hundred pounds in weight have been found in the near vicinity. On account of the stimulus that this find has exerted on the prospecting of the adjacent American territory, the occurrence merits some description in this report. The stripping of the bedrock near the great nugget exposes a face of green basaltic amygdaloid 20 feet high and 15 feet wide. The rock is traversed by numerous seams of native copper along fractures and slickensides, but toward the bottom of the open-cut stringers of chalcocite begin to appear. About 150 feet from this prospect an opening on an independent occurrence shows stringers of cuprite with admixed copper, stringers of glance and calcite, and chalcopyrite disseminated through the amygdaloid country rock. From these features it is clear that the metallic copper of this deposit is a superficial oxidation product of sulphides, that its downward extension is small, and that the prevailing sulphide at greater depth will probably turn out to be chalcopyrite.

At a few localities native copper is associated with certain highly amygdaloidal portions of the Carboniferous basalts and intergrown with the white minerals that fill the former steam cavities in the ancient lava flows. Slaggy looking portions produced by the weathering and removal of the amygdules from the lava and amygdaloid that is cut by small irregular veinlets filled with the same minerals as those forming the amygdules appear to be the most favourable places for metallic copper. The copper in the vesicles and stringers is associated with calcite and delicately spherulitic prehnite, but in some of the veinlets calcite, prehnite, quartz, a black lacquer-like mineral, partly combustible, and chalcocite, instead of metallic copper, are associated together.

At a number of places throughout the region narrow stringers of chalcocite cutting the ancient basalts are encountered, but so far as known none have any great persistence. Near the head of Cross creek, locally known as Copper creek, a thin quartz-chalcopyrite vein cutting the bedded volcanic rocks has been discovered. At other localities some irregularly disseminated sulphides, in some places chalcocite, in others bornite, occur in the basalts, but these do not appear to be connected with definite vein or lode systems, and are consequently of an unencouraging character. Oxidation of these sulphides and disintegration of the containing rock give rise to the nuggets of cuprite and native copper that are found in the talus slopes at several places in the region.

In contrast to these occurrences, which, as shown by the foregoing discussion, are limited to the ancient basalt flows, copper is found as bornite and as chalcopyrite intergrown with contact-metamorphic rock in limestone adjoining diorite intrusives. In deposits of this type the ore mineral is associated with garnet, coarsely crystalline calcite, epidote, specular hematite, and scattered flakes of molybdenite. The garnet is commonly crystallized in dodecahedra, and is intimately intergrown with the bornite and chalcopyrite. On account of its weight and especially its appearance, which is not unlike that of cassiterite, it was mistaken for tin ore by some of the early prospectors. Only two deposits of this character were seen in place, but evidences of energetic contact metamorphism were detected at a number of other localities. An extensive contact zone has been produced along the junction of the diorite and the massive limestone exposed on the ridge west of Copper pass. Various contact-metamorphic rocks, pyritiferous as a rule, are present in this zone, and these rocks on oxidizing give rise to large iron-stained outcrops, which contrast strongly with the surrounding white limestone. In connexion with the discussion of the contact-metamorphic deposits, it may be stated that the writers were shown some specimens of copper ore containing abundant large octahedra of magnetite and blebs of chalcopyrite in a gangue of coarse calc spar. This ore was undoubtedly obtained from the vicinity of an intrusive diorite-limestone contact, but whether commercially valuable ore bodies of this character exist in this region, which is so remote from transportation facilities, is yet to be demonstrated, in view of the fact that copper deposits of contact-metamorphic origin are characteristically bunchy and low grade.

Conclusions

The White-Nabesna region can be more easily prospected in some respects than many other parts of Alaska, on account of the relative abundance of bedrock exposures. Most of the showings of ore found thus far are situated well up on the mountain sides, generally beneath walls of rock cliffs and above the encumbering talus slopes. This is, of course, to be expected in a region that is incompletely prospected, but it entails the disadvantage that the prospects are located far from timber. The greater number of the copper prospects are found in the Carboniferous basaltic amygdaloids, a relation which is also essentially true for those of the Chitina country. The geologic investigation of the region has established the fact that these volcanic rocks have a considerable distribution, and underlie the greater part of the Wrangell mountains. Much of this territory, however, is unfortunately not accessible on account of its numerous glaciers and extensive ice-fields.

The main interest of the White-Nabesna region has centred in the occurrences of native copper. No phenomenal ore bodies have yet been discovered, but it has been shown that primary native copper occurs in the amygdules of zeolitic amygdaloids, a mode of occurrence unknown on the Chitina side of the Wrangell mountains. This discovery is sufficiently encouraging to warrant further development, and it is hoped that the nature and extent of the deposit will soon be demonstrated.

From the descriptions given in the preceding pages, it will be apparent that a lode-quartz region of some promise has been discovered in the Nutzotin mountains, near the International Boundary, and that, as yet, it has been but imperfectly explored by the prospector. It was shown that the intrusion of quartz diorite produced a number of contact-metamorphic bodies of copper sulphides, and the occurrence on Jacksina creek suggests that the magma was also capable of effecting an auriferous mineralization. From the meagre data at hand it is perhaps unsafe to venture on generalizations, yet it is probable that the quartz veins are genetically related to the intrusion of the post-Carboniferous quartz diorites and that, therefore, the intruded areas are those most likely to be mineral bearing. Such areas are known to occur throughout the Nutzotin mountains at a number of localities, especially along the northeastern flanks. Brooks has mapped a large area of granular intrusive on the lower Nabesna. It is probable that in the vicinity of such masses the search for lode quartz may be prosecuted with the most hope of success.

THE WHEATON RIVER DISTRICT, YUKON TERRITORY

by D. D. Cairnes

The season of 1909 was devoted to mapping and geologically investigating a portion of southern Yukon, extending 5 to 7 miles on each side of Wheaton river, commencing 6 miles above its mouth at Lake Bennett, and continuing over 20 miles up stream. This tract flanks the Coast range of mountains on their eastern side; while its southern edge is from 12 to 15 miles north of the 60th parallel of latitude (the British Columbia-Yukon boundary).

During the summer of 1906 I surveyed and examined a portion of the Conrad and Whitehorse mining districts*, including Windy Arm and the mining properties in the vicinity, and the lower stretches of Wheaton river. Since this was completed, a large number of mineral discoveries have been made along this latter stream. Some are situated in the western part of the area described in the above-mentioned report; but the majority are farther west. In fact, promising showings are to be found in various places, nearly to the headwaters of the Wheaton. The belt investigated during the past season includes all the known promising mineral properties south of the Whitehorse Copper Belt, and east of Windy Arm and the White Pass and Yukon railway.

Claims have been staked in nearly all parts of the district surveyed this past season, and, in spite of the extremely small amount of assessment or development work of any kind that has, in most places, been performed, several properties present a very encouraging appearance. Considering how slightly the district has been prospected, it is somewhat remarkable that so many deposits of ore have been found; and it is improbable that the best, or more than a small portion of all the valuable deposits has yet been discovered.

As soon as transportation charges on the railway have been reduced, so that outfits and supplies may be obtained at a more reasonable cost, and ore and concentrates shipped out at a moderate rate, there can be little doubt that prospecting and mining will be stimulated, resulting in a number of these properties becoming important producers.

A base-line, about two miles long, was measured along a tangent on the White Pass and Yukon railway, commencing about half a mile north of Robinson. From this base a triangulation was carried over the district. The topography was filled in chiefly by the photo-topographic method, aided to

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* Cairnes, D. D., Geol. Surv., Canada, Report on a Portion of the Conrad and Whitehorse Mining Districts, Yukon Territory.

some extent by plane-table traversing. This latter method was also employed in surveying all roads, trails, etc.

During the season, I was assisted by E. W. Banting, B.A.Sc., and W. A. Bell, who performed in an efficient manner the greater portion of the topographical part of the work. Mr. Bell also assisted, at times, in the geological work.

Topography

The district described in this report is included in the western portion of the Yukon plateau, and extends westward to the eastern edge of the Coast Range mountains. This plateau province, which has been described in previous reports*, is strikingly developed along the Wheaton river. It is quite evident that the rolling expanse of almost featureless upland is a portion of a recently unlifted, and subsequently, deeply dissected, almost base-levelled surface. The general level of this elevated tract is from 2,500 to 3,000 feet above the main intersecting stream beds, or 5,750 feet above sea-level. Occasional monadnocks, or generally rounded hills, rise in places above the surrounding expanse of upland, and constitute the only considerable inequalities which subaerial erosive agencies have left to break the monotony of the planated surface. The geological formations have no relation to, and do not accord with, the land surface, the formations being, as shown farther on in this report, of various origins, ages, textures, attitudes, etc.

The walls of the main valleys are generally steep, forming almost perpendicular declivities at numerous points. This feature of the topography has been accentuated and produced, in some instances, by glacial action. The main ice masses occupied these depressions and were effectual in straightening them and planing the slopes, and in widening and lowering their floors; causing the valleys to be wide, deep, and steep-sided. The smaller tributary streams flow with gentle gradient in wide, shallow depressions, over the upland surfaces, but generally plunge suddenly over the edges, by a succession of falls, through ravine-shaped incisions, to join the main streams below.

Numerous well defined terraces, at various elevations up to 700 or 800 feet above the stream beds, extend along the Wheaton valley and along Partridge pass, Becker creek, and others of its main tributaries.

Below the Big Bend of the Wheaton, the river valley has an average width of about one mile. Above the Big Bend, however, it is generally only one-quarter to half a mile wide. The stream itself is still active, removing the glacial gravels, sands, clays, etc., which, at one time, filled the valley to a depth of several hundred feet. The river channel is exceedingly tortuous, the course of the stream being easily altered in these slightly resistant glacial materials. The valley walls rise abruptly 2,500 to 3,000 feet on each side.

Flora and Fauna

The district is but sparsely forested: trees and shrubbery growing principally in the valley flats, and seldom extending up the hillsides more than 700 or 800 feet above the main depressions. The only trees of any

* D. D. Cairnes—Report on a Portion of the Conrad and Whitehorse Mining Districts, Yukon. Summary Reports of the Geol. Survey Branch- 1906, 1907, 1908.

considerable size are the white spruce (*Picea alba*); black pine (*Pinus Murrayana*); and balsam fir (*Abies subalpina*); the spruce being by far the most plentiful. Some good groves of the latter species, straight and well grown, were noted in the valleys, the trunks seldom being larger than 12 inches in diameter, 3 feet from the ground. Black pine is occasionally found interspersed with the white spruce, or at times forming separate groves, either in the valleys or on the hillsides. The balsam fir is generally on the slopes near timber-line. The two latter varieties seldom have more than a 10-inch stump. Willow (*Salix*); dwarf birch (*Betula glandulosa*); aspen poplar (*Populus tremuloides*); balsam poplar (*Populus balsamifera*); and western balsam poplar (*Populus trichocarpa*); cover a considerable portion of the valleys, and are found on the majority of the sidehills up to an elevation of 4,000 feet above sea-level. The dwarf birch, in places, also extends to the main plateau line.

Several varieties of wild fruit were noted in the district: mossberries; high-bush cranberries (*Viburnum pauciflorum*); and low-bush cranberries, were quite plentiful in places, also black currants (*Ribes Hudsonianum*); red currants (*Ribes rubrum*); gooseberries; blueberries (*Vaccinium*); strawberries (*Fragaria cuneifolia*); raspberries, and Saskatoon berries (*Amelanchior florida*) were noted.

Moose and sheep are fairly plentiful in many localities, as are also black, and grizzly bears. Caribou are less often seen. Wolves, wolverine, beaver, otter, marten, and lynx, are somewhat common. Cross, black, and silver foxes are also occasionally found. Ptarmigan exist in great numbers on the higher elevations, and grouse of different varieties are fairly plentiful. Rabbits, which a few years ago were so abundant, are now very scarce.

The streams and lakes are generally well supplied with grayling and trout.

Climate

The climate of southern Yukon is similar to that of many districts in British Columbia and other northerly but prosperous mining camps of the world, and in actual mining few more climatic difficulties have to be overcome, here, than in localities farther south. All necessary outside and surface work in connexion with mining and similar industries may be continued at least six months in the year. Besides, on account of the very long days at this northern latitude, surface work may be performed during a considerable part of the summer by night as well as by day, without the aid of artificial light. The ground, in many places, is continually frozen to varying depths, but this does not interfere with mining operations, except while work is being done at or near the surface.

The rivers generally open early in May, but on some of the lakes the ice remains until the first week in June. Slack water stretches freeze over any time after the middle of October, but occasionally the rivers remain open until well on in November.

Transportation and Communication

Two wagon roads have been built from Robinson, on the White Pass and Yukon railway. One leads to Gold hill, a distance of 20 miles, and the other, which is over 30 miles long, extends up Wheaton river. From these and branch roads, which can readily be constructed, access can be had to all parts of the district, the different mining claims being from 12 to 35 miles distant from the railway. A road could also easily be built, if necessary, down the Wheaton valley to Lake Bennett, along the eastern side of which the railway has been constructed. There is also an exceptionally good grade for a railway, to near the headwaters of Wheaton river, from either Robinson or Lake Bennett. The White Pass and Yukon railway connects at Skagway with lines of boats sailing to Vancouver and Seattle.

General Geology

The geology of this district is somewhat complex, and many types of rocks are represented, including sedimentary, metamorphic, volcanic, and plutonic. Highly altered schists, gneisses, and limestones, as well as more recent andesites, have been extensively invaded by granitic rocks. This complex is overlain by Jurasso-Cretaceous sediments which have been intruded, and, in part, buried in turn by andesites, andesitic tuffs, eruptive breccias, granite and syenite porphyries, and basalts. Newer than all these is a widespread series of trachytes, rhyolites, tuffs, and breccias, which are hidden in places by superficial deposits.

Table of Formations

Quaternary	Superficial deposits	Gravels, sands, silts, clays, volcanic ash, etc.
Pleistocene and late Tertiary	Wheaton River volcanics	Rhyolites, trachytes, tuff, breccias, etc.
	Carmack basalt	Basalt and basalt tuffs.
	Klusha intrusives	Granite and syenite porphyries.
	Chieftain Hill volcanics	Andesites, tuffs, and breccias.
Jura-Cretaceous	Tantalus conglomerate	Chiefly conglomerates with some sandstones, shales and coal seams.
	Laberge series	Conglomerates, greywackes, sandstones, shales, etc.
Jurassic	Coast Range intrusives	Granites, granodiorite, and diorites.
	Perkins volcanics	Andesites and andesitic tuffs.
Lower Palæozoic or older	Mt. Stevens series	Schists, gneisses, and limestones.

Mount Stevens Series

The oldest rocks comprise a series mainly of chloritic, sericitic, and greenstone schists, schistose, quartzites, limestones, and gneisses. The schists are chiefly fine-grained, greenish, chloritic rocks, varying in structure from highly fissile to but slightly schistose. The sericite schists are generally soft and friable, yellowish to greyish in colour, and finely foliated in structure. The greatest thickness of limestone beds occurs on Schist mountain, where they have an aggregate thickness of approximately 700 feet; the rock varying from white to bluish, and from subcrystalline to crystalline. The most prominent gneisses are fine-grained mica gneisses and coarsely crystalline rocks presenting the appearance of crushed gabbros. All these rocks, which are believed to be of lower Palæozoic age or older, have been much altered and plicated, and occur in the form of small isolated areas brought up as infolds in the newer rocks- chiefly in the granites. A considerable portion of the ores of the district occurs in the schists of this series.

Perkins Volcanics

More recent than the Mount Stevens group is a very homogeneous series, the Perkins series, consisting chiefly of considerably altered, hard, fine-grained, dark-greenish, andesites and andesitic tuffs.

Coast Range Intrusives

Invading both of the above-mentioned series are numerous outlying areas of the granitic rocks of the Coast Range batholith, believed to be of Jurassic age. These rocks are generally fresh and unaltered in appearance, predominantly greyish in colour, and under the microscope prove to be generally granodiorites. In places they are quite porphyritic -feldspar phenocrysts $1\frac{1}{2}$ to 2 inches long having been frequently noted. The greater number of the quartz veins of the district are found in these granitic rocks.

Laberge Series

Newer than the granites are the rocks of the Laberge series of Jurasso-Cretaceous age, which consist of shales, sandstones, greywackes, conglomerates, and breccias. These beds are similar to those seen along Lake Laberge and elsewhere in the Braeburn-Kynocks and Tantalus coal areas. Medium textured, greenish-grey, heavily bedded greywackes frequently alternate with fine-grained shales and slates. The conglomerates consist chiefly of volcanic materials, the component pebbles and boulders—which are as much as 6 inches in diameter -being usually firmly cemented together. It is in the greywackes of this series that the ores of the Union mines have been deposited.

Tantalus Conglomerate

Resting conformably on the Laberge beds are those of the Tantalus conglomerate series, which have here an aggregate thickness of 300 to 400 feet. These conglomerates, etc., which are associated with all the bituminous and anthracitic coals so far discovered in southern Yukon, have been described in the author's previous reports on this territory. The series consists chiefly of generally dark coloured, heavily bedded conglomerates, the component pebbles of which consist entirely of chert, quartz, and slate. Associated and interbedded with the conglomerates are a few beds of sandstone and shale, and coal seams. The sandstones are composed, chiefly, of the same materials as the conglomerates, but in a more finely-divided state. The shales vary from light grey to almost black, are generally thinly laminated, and grade into typical slates.

Chieftain Hill Volcanics

Cutting all the above-mentioned formations is a series of mica-hornblende, and augite andesites, andesitic tuffs, breccias, etc. They occur in some places chiefly as dikes, but in others form quite extensive sheets and flows. They vary from mica andesites, with greenish-grey to reddish groundmass, in which are well defined plagioclase and biotite phenocrysts, to fine textured, dark green basaltic-appearing augite andesites. They correspond to, and include the members of, the Schwatka and Hootchi series of the

Braeburn-Kynocks and Tantalus coal areas; but the characteristics that served to distinguish these formations in these latter localities are not here in evidence.

Klusha Intrusives

Newer than these andesites are numerous dikes of granite and syenite porphyry, from 4 or 5 feet to several hundred feet wide. These are generally light grey, coarsely crystalline rocks, and correspond to the 'Klusha Intrusives' of the Lewes and Nordenskiöld Rivers coal districts.

Carmack Basalt

Dikes and sills of a medium textured, dark coloured basalt, occur in numerous places, and cut all the above-mentioned formations. This basalt is similar to that seen to the north, in Miles cañon, and at other points in the vicinity of Whitehorse, also in the Tantalus coal area, farther north, and has, in the latter district, been included in the 'Carmack Basalts'. These rocks and the Klusha intrusives are considered to be of late Tertiary age.

Wheaton River Volcanics

The most recent consolidated rock formation of the district consists of a series of trachytes, rhyolites, tuffs, breccias, etc. These are prevailingly light yellow in colour, becoming reddish in places owing to the oxidation of small particles of iron pyrites. They are generally soft, and weather and decompose readily, breaking, as a rule, into thin slabs. The mountain slopes on which these rocks outcrop—when seen from a distance—are bright yellow or red in colour, and are invariably covered with talus.

Superficial Deposits

The main valleys in this district are floored with glacial deposits, which generally reach well up on the hillsides, extending in places even to the higher elevations. The channels of the main streams are entirely in these gravels, sands, silts, etc., insufficient time having elapsed since their deposition for the water to remove them from these depressions. In fact, some of these principal pre-glacial waterways are still completely filled with such material. Overlying these Pleistocene deposits are more recent accumulations, composed of fluvial and littoral sands, gravels, and silts of the present waterways; muck, volcanic ash, and soil. The volcanic ash, which has been mentioned in nearly all reports on any portion of southern Yukon, is a notable feature in this district, consisting of a single, very evenly distributed and widespread layer, which is 3 to 6 inches thick along Wheaton river, and evidently due to one continuous, but short period of outburst. It is much more recent than the silts—the most recent of the glacial deposits; in fact, it is almost at the very surface, the grass roots extending down into it.

Economic Geology

With the exception of some coal seams found in one locality, this district, from the standpoint of economic geology, is of interest chiefly for its ore deposits. These might be arranged under three classes:

(1) Quartz veins generally carrying galena, and in places, telluride minerals, chiefly sylvanite and telluric ochre. Arsenopyrite, zinc blende,

pyrite, grey copper, bornite, chalcopyrite, malachite, azurite, etc., may or may not be present in small amounts.

(2) Fissure veins composed chiefly of stibnite with inferior amounts of zinc blende, in either a quartz or a calcite gangue.

(3) Contact deposits.

Deposits belonging to this last class have been found only on one property; but the veins occur in all parts of the district, those carrying antimony minerals being, however, limited to the extreme southwestern portion of the area.

The mining properties are here considered in order, from east to west.

Union and Nevada Mines

The Union Mines properties were located a number of years ago, and a general description of them has already been published*. They are situated on the east face of Idaho hill, and consist of three claims on which are a number of nearly parallel veins occupying fissures in a fine-grained, greenish-grey greywacke. The majority of the veins have a general strike of N. 67° W,** and dip from 60° to 80° to the southwest. Ten veins in all were seen, having an average width of 4 inches to 12 inches; and others probably exist. The minerals are chiefly galena, arsenopyrite, zinc blende, pyrite, and chalcopyrite, and occur in a quartz gangue. Several veins from 8 inches to 10 inches thick, and highly mineralized with galena, arsenopyrite, and zinc blende, were noted. The thickest discovered is 30 inches, and consists, on the surface, of decomposed material, chiefly quartz, pyrite, and galena. These ores generally carry some gold, but are chiefly of value for their silver and lead contents. All the work performed on these properties is of the nature of surface prospecting.

The Nevada Mines are a group of claims adjoining the Union mines. Several quartz veins showing some arsenopyrite, pyrite, galena, and zinc blende, have been found in them, and, to some extent, have been developed.

Stevens Mountain Claims

The Buffalo Hump Group, owned by Mr. George Stevens, and consisting of the Sunrise, Golden Slipper, and Wheaton—all located on the north side of Stevens mountain—are probably the most widely known claims in the vicinity.

On the *Golden Slipper* claim, several hundred pounds of very rich quartz have been found, containing free gold and sylvanite. Although, when visited in August, the surface had been prospected somewhat carefully and a drift 85 feet long, with a 20-foot cross-cut had been driven, the source of the high grade float ore had not been discovered. The formation is chiefly granite.

On the *Sunrise* claim is a 7-foot quartz vein in a fissure in granite, which carries some galena and free gold. Little prospecting has been done here, hence it is not known, even approximately, how much gold and silver the average quartz carries.

On the *Acme* claim, owned by O. Dickson, is a lenticular quartz vein,

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* Cairnes, D. D. Report on a portion of the Conrad and Whitehorse Mining Districts, Yukon.

** All bearings in this report are astronomic, or true, the magnetic meridian being generally about 33° to the east of the astronomic.

in chloritic schist, the quartz being in one place over 30 feet thick. It appears, however, to be very slightly mineralized.

On the *Hawk Eye* group of three claims, owned by the 'Tally-Ho Boys', and situated on the Wheaton River slope of Stevens mountain, are two quartz veins averaging 20 inches, and 3 to 4 feet, respectively, in thickness, which have been prospected to some extent.

On none of these claims on Stevens mountain has ore been found in place so far, rich enough to pay for mining. Still, extremely rich float has been found near the summit of the hill in several places; and from the size, angular character, and amount of the material, it is quite evident that it has come but a short distance, and belongs to the hill on which it is found; so that it is hoped that the vein or veins from which it is derived will be discovered.

Big Bend Mountain Claims

The *McDonald Fraction*, which is situated near the western edge of Big Bend mountain, is probably the best appearing prospect on this hill. Outcropping on it, and occupying a fissure in granite, is a 2-foot vein of quartz, well mineralized, chiefly with argentiferous galena, which, it is claimed, contains gold and silver in very encouraging amounts.

The *Silver Queen and Gopher* claims are on the west side of Big Bend mountain, near the McDonald Fraction, and are the principal claims in a group of seven, owned by the 'Tally-Ho Boys'. On the former is a 3-foot vein of quartz in granite, and on the latter in greenstone schist is a lenticular vein, which, at one point, is as much as 7 feet thick. These veins are reported to carry important amounts of gold and silver.

The Tally-Ho Group

On the west side of the Tally-Ho gulch, which extends along the western end of Big Bend mountain, the 'Tally-Ho Boys' have located eight claims. The development work, for this group, all of which has been performed on one claim, consists of a 250-foot drift; a 10-foot winze; a 40-foot raise, and a cross-cut about 15 feet long. The ore occurs in a brecciated fault zone 4 to 5 feet wide in the granite formation, and consists of a quartz gangue impregnated with galena, the quartz varying in width from 2 inches to 4 feet. Of five assays of samples taken by the author, the average was close to $80 per ton in gold and silver.

Becker Creek Claims

On the east side of Becker creek, and on the west face of Anderson mountain, is a strong, well-defined quartz vein, 4 to 5 feet wide, contained in a fissure in granite. The strike of the vein is, approximately, N. 68° W, and its attitude is nearly vertical. It can be traced nearly the entire length of the Rip and Wolf claims, and, in most places, is well mineralized with argentiferous galena. A basalt dike 2 feet wide has split the vein, and continues in it, for at least 2,000 feet.

On the *Rip* claim, owned by Wm. McGrew, a drift 90 feet long has been driven on the vein, the basalt dike in this distance crossing from one side of the ore to the other. The quartz obtained here should pay to work even under present conditions.

On the *Wolf* claim, owned by Messrs. Clark, Dickson, and Johnson, the basalt dike splits the vein into two about equal parts. Approximately 40 feet of open-cutting and drifting have been performed on this property.

The *Fleming* claim, located in July, 1909, by Mr. H. E. Porter, is situated on a small hill on the west side of Becker creek, and facing the Wheaton river. Here, certain beds of gneiss, which constitute a portion of the old pre-Ordovician series, have been more or less replaced by quartz, calcite, epidote, garnet, hematite, magnetite, pyrite, and chalcopyrite with its oxidation products azurite and malachite. The schists strike N. 42° W, and dip at 60° to 70° to the northeast. To such a degree has the replacement proceeded that for a width of 30 feet, one schist band has been almost entirely altered to iron and copper minerals, with some epidote, quartz, etc. The 30 feet probably average about 1 per cent copper. Other similar but narrower bands were noted.

The origin of the ore is almost certainly directly due to the invasion of the granites which outcrop along the south side of the hill.

Claims on Gold Hill and Vicinity *

Considerable excitement was caused during the season of 1906 by the finding of quartz carrying free gold and telluride minerals on what is now the Gold Reef claim on Gold hill—midway between the Watson and Wheaton rivers, and 20 miles southwest of Robinson.

Since 1906, considerable development has been conducted on the *Gold Reef;* but only a few pockets, from the size of a man's head, to one of 500 or 600 pounds of the rich ore—which contains free gold, sylvanite, hessite, and telluric ochre—have been found: elsewhere, the vein, which is 4 or 5 feet wide, is almost barren, containing only occasional disseminated particles of pyrite, and but slight amounts of gold and silver.

Of the large number of other claims which were located in this vicinity in 1906, the only one on which any development work, other than assessments, has been performed is the *Legal Tender.* The vein on this property is in a fissure in granite, and is 3 feet to 3 ft. 6 ins. thick, and consists of a quartz gangue in which are disseminated particles of argentiferous galena and chalcopyrite. The ore is claimed to have an average value of $40 per ton. A 100-foot drift has recently been driven on the vein.

During a recent assessment on the *Lucky Boy* prospect, a quartz vein—at least 7 feet wide—was uncovered, which carries some copper glance, chalcopyrite, and malachite. As the vein is only stripped for a distance of 6 feet, very little information concerning it is available.

Carbon and Chieftain Hills, and Vicinity

A number of claims were staked on these hills during the season of 1893 by two prospectors: Frank Corwin and Tom Kirkman; who, during the season, did considerable prospecting work on them. These men did not return again, and the ground remained vacant until rediscovered in August 1906, by Mr. H. E. Porter, who located eighteen claims on the hills. This caused a general stampede to the vicinity, resulting in the staking of a great number of claims.

A large proportion of these claims, located during this rush, are still held, but on only a few has any work, other than assessment, been performed.

Mr. Porter and Mr. William J. Fleming, of Chicago, own three claims on Carbon hill, namely, the Porter, the Empire, and the Excelsior, which have recently been surveyed. On the Empire are the old workings—now

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* D. D. Cairnes—A Portion of the Conrad and Whitehorse Mining Districts, Yukon.

caved in—of Corwin and Kirkman. On the Porter claim a drift is being driven to cross-cut a number of parallel veins, and when measured on August 20, was in 160 feet. The veins which are all in fissures in granite, strike about N. 77° W, and dip from 40° to 50° to the northwest. The best appearing one of these varies from 14 inches to 3 feet in thickness; can be traced over 200 feet on the surface, and has every appearance of extending much farther. The ore appears to be chiefly stibnite and sphalerite, in a quartz gangue. In places there are 12 to 14 inches of stibnite, with very little gangue mineral. Five feet below this vein is another, from 6 to 12 inches thick, and similar to the former, but not so highly mineralized. There are also two other veins within a few feet, which are from 2 to 6 inches wide, and consist of quartz with small disseminated particles of galena and grey copper, and, apparently, no antimony minerals. Samples from these two veins have assayed as much as $80 per ton in gold and silver. In a gulch on the north side of Carbon hill, Mr. Charles Goddell has located some claims on two parallel veins which are not more than 20 or 30 feet apart, and are exposed for over 2,000 feet. These strike N. 80° W, have an almost perpendicular attitude, consist chiefly of quartz carrying some stibnite and arsenical iron, and are 2 feet, and 2 to 6 feet thick, respectively.

Besides the above-mentioned, a number of other veins from 6 inches to 2 feet thick, were noted. These are more or less highly mineralized, chiefly with antimony minerals, and occur, not only in the granite, but also in the overlying sedimentaries.

The two main claims on Chieftain hill are the Morning—owned by Messrs. Anderson and Eisenhauer; and the Evening—owned by Messrs. Dixon and Johnson. These properties are located on the same vein, which, near where it crosses Chieftain gulch, is 5 feet wide, and consists of quartz highly impregnated with stibnite; a portion of the vein—2 feet wide—being almost entirely composed of this mineral, which exhibits beautiful columnar and radiated structures. Fifty feet from this place, in each direction, the vein has narrowed to from 6 inches to 1 foot. This vein is in a fissure, in a fine-grained, greenish andesite; it strikes almost due east and stands nearly perpendicular.

Bush Mountain Coal Area

The Tantalus conglomerates which, in the southern Yukon, are known to be coal-bearing, were found outcropping about one mile west of the Union mines, on the ridge joining Bush mountain and Idaho hill, and search was made for coal, which, if found in this locality, would be of considerable value. Three seams were discovered: one over 6 feet, one 18 inches, and one of unknown thickness, but at least 3 feet. There were indications of other seams; but as the ground was frozen and the coal deeply covered, to have made a section of the measures, or even to have determined the thickness of the different beds of coal, would have entailed a very considerable amount of work. The measures were traced from the summit of the ridge to near the valley bottoms of Schnabel and Follé creeks on the south and north sides respectively. These creeks are here two miles apart, and, opposite the coal, are about 2,000 feet lower than the summit of the ridge between them. The belt of coal-bearing formation is about half a mile wide, and the rocks comprising it are much folded and disturbed. The coal, which is bituminous, and of the same age as that at Whitehorse and Tantalus, should make a good fuel.

Quartz Claims East of Whitehorse

After the close of the regular field season, a visit was made to certain quartz claims east of the Lewes river, near Whitehorse.

These claims are situated near the summit of one of the most southerly of the limestone hills in the range facing the town of Whitehorse on the east. The Lewes river, after flowing along the southern end of this range, turns suddenly at nearly right angles, and continues toward the north along its western face. Hence, the claims, being on the southwest corner of the range, are about equidistant from the river in either a southerly or westerly direction. They are about 8 miles in a direct line, or 12 miles by trail, in a southeasterly direction from Whitehorse; and the shaft on the Golconda claim is approximately 1,600 feet above the level of the town.

A good pack train, 7 miles long, has been built to these claims from Canyon City at the head of Miles cañon. Canyon City is situated on the east side of the Lewes river, on the opposite side of the river from, and five miles above, Whitehorse. A good grade is obtainable for a wagon road from the claims to the river, either at Canyon City or other points above or below: the claims being nearest the river at points a few miles above Canyon City.

The claims themselves and the greater portion of the higher elevations in the vicinity are exceptionally well forested for this portion of the Yukon Territory. The principal timber trees are the white spruce (*Picea alba*), and balsam fir (*Abies subalpina*), the former being more abundant than the latter. Trees with 16-inch stumps were noted, and those with 14-inch to 16-inch stumps are fairly plentiful. The average, however, of the larger trees is not more than 10 inches in diameter, 3 feet from the ground.

There is also an abundant supply of water on the properties.

All the rocks seen on the claims and on the hills in the vicinity belong to the limestone series which outcrops so extensively along Tagish lake; in the neighbourhood of Whitehorse; along the Lewes river; and elsewhere in the southern Yukon. Although not positively proved, it has been supposed* that these rocks are of Carboniferous age. These limestones are, as a rule, very uniform, and generally appear as heavily bedded, subcrystalline rocks, varying from dark grey to almost white, but prevailingly light grey in colour. The chief impurities in them consist of small siliceous—at times cherty—aggregates. Rarely, beds of somewhat arenaceous or argillaceous material occur in the form of calcareous shales, and it is in a series of these that the quartz has been deposited, along which the Golconda group of claims has been located.

The Golconda group consists of four claims: the Golconda, Florence M., Concord, and Mohawk, all of which have recently been surveyed. The first two were located by Mr. Arthur Thompson in 1899, and are still owned by him. The other two have been located since and are owned by Mr. P. Campbell, of Whitehorse.

The quartz along which these claims are located occurs in a soft, friable, thinly bedded, somewhat iron-stained, calcareous shale, which will often split into large flakes $\frac{1}{16}$ to $\frac{1}{8}$ inch thick. These shales have a total average

* G. M. Dawson—Report of Progress, 1887. R. G. McConnell—Report on Whitehorse Copper Belt, Yukon Territory, and D. D. Cairnes—Report on Portion of the Conrad and Whitehorse Mining Districts, Yukon.

thickness of about 100 feet, and are interbedded in the typical heavily-bedded limestones, which strike N 41° W and dip 40° to 50° to the northeast. Veinlets of quartz traverse these shales in all directions, the majority, however, following the bedding planes, and, in places, they become plentiful enough to form considerable masses of quartz. In places, a great part of the entire 100 feet is more or less invaded by these veinlets; individual stringers widening out occasionally to several feet thick. The greatest amount of quartz occurs near the centre of the shale belt, where for a width of from 6 to 26 feet it is almost free from rock; the material for a few feet on each side also consists to a greater or less extent of interlacing quartz stringers. This constitutes the Golconda vein, which can be traced the entire length of the four claims staked along it, which comprise the Golconda group.

The main group follows the general strike of the shale and limestone beds, and its dip appears to coincide with that of the enclosing strata.

The quartz, being much harder than the shales, weathers less readily, hence it stands out as a ridge from 4 to 12 feet high.

That the quartz is entirely confined to the shales and is not found elsewhere is, apparently, entirely due to the fact that, the solutions carrying the quartz found greater facilities for circulation through these soft, friable, thinly bedded materials than through the more compact, heavily bedded limestones. Moreover, the shales have, naturally, been more shattered, crushed, and broken than the stronger beds on either side; thus giving additional fractures and planes of circulation in the shale belt for the invading solutions.

Nearly all the work in this group has been performed on the Golconda claim, and consists chiefly of a vertical shaft, apparently 60 or 70 feet deep. The shaft may be somewhat deeper than this, however, as when it was visited it was impossible to see the bottom on account of water. A few small cuts, etc., comprise the remainder of the development work on the group.

Except close to the Golconda shaft the quartz is apparently entirely devoid of mineralization except for rarely seen particles of free gold and a slight amount of pyrite, which, in weathering, gives the quartz in places a somewhat reddish appearance on the surface. Close to the Golconda shaft the quartz contains some disseminated particles of chalcopyrite, and its oxidation product malachite.

It is claimed that assays as high as $40 a ton in gold have been obtained from this quartz. I made, however, two carefully taken, average surface assays: one at the top of the Golconda shaft, and the other from a place on the Mohawk claim, where some work has been done. Large samples were taken, and carefully quartered down. These were assayed by the Mines Branch, and in each case the result gave only traces of gold and copper. The Mohawk sample ran only a trace in silver; but the one from the Golconda claim gave 0·11 ounces silver to the ton.

It is possible that these samples do the properties injustice, as it is well known how difficult or next to impossible it is, in the case of a vein of free-milling quartz, to obtain a correct estimate of its value from the results of a few samples. A great many samples must be taken, and, when possible, a few tons of the material treated, before it is possible to decide as to its worth.

Williams and Merritt Creeks

After completing the work in the vicinity of Whitehorse, a few days were spent on Williams and Merritt creeks, where recent copper prospects are attracting some attention.

Merritt creek empties into Lewes river on its left limit, five miles below Yukon Crossing; while Williams creek joins the river one mile farther down. These two creeks, for several miles from their confluence with the Lewes, have almost parallel courses, at practically right angles to this river. Yukon Crossing is about 155 miles from Whitehorse, measured along the Whitehorse-Dawson wagon road, and 230 miles from Whitehorse, by the river, and is midway between Whitehorse and Dawson.

Merritt creek was formerly known as Merrice creek; and was so called after Homer Merrice, who discovered placer here in 1898. By a mistake, and believing it to be the original, the present name has been adopted. Williams creek is named after a prospector by that name, who was one of the first to locate on this creek in 1898.

During the season of 1898 these creeks were prospected for quartz and placer, for 25 miles from the Lewes river, and the old workings of this time can still be seen in many places. From then until 1907—when practically all the claims now being held were located—the district was unoccupied.

The only two rock formations which exist at all extensively in this district consist chiefly of granites and amphibolites. The latter are the older and are much altered, dark green, sheared eruptives, which consist chiefly of plagioclase and green hornblende, in nearly equal amounts. The schistose structure is generally quite pronounced; still, the rocks are practically never thinly foliated. The granites are generally greyish to pinkish, coarsely crystalline rocks. A thin section of a typical specimen examined under the microscope showed it to be composed chiefly of orthoclase, microcline, acid plagioclase, quartz, and biotite, with accessory apatite, titanite, and magnetite, and a great amount of secondary epidote and chlorite. In all probability, these granites belong to the series of granitic rocks composing the Coast Range batholith, which are generally considered to be Jurassic. The amphibolites lithologically correspond to certain pre-Ordovician rocks which have been studied in the vicinity of Dawson*, and elsewhere in the Yukon Territory.

The granites have invaded the amphibolites to such an extent that the outcrops of the two formations appear to be about equally extensive: tongues, dikes, and irregular-shaped masses of the former being found everywhere, where rock, in place, is to be seen.

The ore deposits of this locality occur either at or near the contacts of these two formations, and are everywhere of the same character, consisting of veins of quartz impregnated with copper minerals, chiefly bornite, chalcopyrite, and malachite. Particles of free gold are also believed to have been found on one property. The only apparent reason for the quartz being always so near the contact is, that the mineralizing solutions which have deposited the ores have found easier places for circulation in these somewhat decomposed and fractured zones. The ores are apparently genetically connected with the granites, the ore-bearing solutions being an after effect of the intrusion of the granite mass.

The ores of the district are all of such a nature as to lend themselves readily to treatment by concentration.

All the claims and copper grants in the vicinity, on which any work has

* R. G. McConnell. "The Yukon Gold Fields", Geol. Survey Branch, Canada.

been performed, or on which any ore is known to have been discovered, were examined. The only ones, however, on which any considerable amount of ore was seen, or which, from their surface showings, give promise of being of value, are the Bonanza King, the Homestake, the Monte Cristo, and the Dawson. It is quite possible, and even probable, that there is a considerable amount of ore in this locality which has not yet been discovered, since the surface is, in most places, covered with superficial deposits.

The *Bonanza King* is situated about one mile from the Lewes river, on Nancy Lee creek—a tributary of Williams creek—joining the latter on its left limit. This property is one of eight claims comprising the Bonanza King group, owned by Messrs. J. Munroe, J. View, and M. H. Boulais. All the development work on the group has been performed on the Bonanza King and Dawson claims. The work on the Bonanza King consists of 150 feet of drifting and cross-cutting, and a 30-foot shaft. The entrance to the drift is 250 feet above the level of the Lewes river, at the mouth of Williams creek; and the top of the shaft is 250 or 300 feet distant from the mouth of the drift, and 200 feet above it.

The shaft is sunk on a vein of quartz which is 6 feet wide at that point; but is lens-shaped and narrows rapidly in each direction. The vein is in granite, near its contact with the amphibolite, and carries considerable bornite, chalcopyrite, and malachite. Particles of free gold are also believed to have been found here. Two samples of the better mineralized portions of the vein, one taken near the surface and the other about 15 feet from the surface, were assayed, and gave, respectively, the following results*: (1) gold—trace; silver—trace; copper, 3·29 per cent; (2) gold—trace; silver—trace; copper, 4·21 per cent.

The vein in the drift occurs in the contact between the granites and amphibolites, and, where first encountered, is wider than elsewhere observed, having a width of 5 feet. It narrows to a few inches in a distance of 20 feet, in the direction in which the drift has been run. It was found, however, on the surface on a level with the drift, and at a distance of 50 feet from where first cross-cut, and has here a thickness of 3 to 4 feet.

Both the vein at the shaft and the one in the drift strike approximately in the same direction: N. 45° W, but are not connected with each other. It is possible that other similar deposits exist along this contact, either between the two already found, or farther to the northwest.

The formation has here been considerably shattered and broken. One very prominent fault plane, indicating a displacement of considerable magnitude, was noted in the cross-cut and drift, having a strike about parallel to the strike of the veins. So that the faulting will serve to further complicate the working of these deposits.

An average sample of the 5 feet of quartz in the drift was assayed, and gave the following: gold, 40 cents; silver, 0·30 of an ounce; copper, 1·56 per cent.

On the *Dawson* claim a 40-foot drift has been driven on a quartz stringer in the amphibolites near their contact with the granite. The quartz, at the surface, was only 2 inches or 3 inches wide, but at the end of the drift was 18 inches. The ore is very similar to that on the Bonanza King.

On the *Monte Cristo* claim, which is also on Nancy Lee creek, and is

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*All assays given in this report were made in Ottawa by the Mines Branch of the Department of Mines, Canada.

owned by Messrs. Thompson and Granger, a vein has been discovered which, where exposed, has a thickness of 5 feet. Within a few feet of this are several parallel stringers a few inches wide. The vein-filling consists chiefly of quartz, bornite, chalcopyrite, and malachite. The surface is covered, nearly everywhere in this vicinity, with drift and the products of weathering and decomposition, making prospecting very difficult; so that the chances of finding ore, at all, are but slight, even though there were a number of valuable veins on this and the adjoining properties.

An average surface sample of this 5-foot vein was assayed, and gave as follows: gold, 20 cents; silver, 0·20 of an ounce; copper, 1·00 per cent.

The *Homestake* is one of six copper grants of 160 acres each, located on Merritt creek, and owned by Messrs. C. L. Johnson, Chas. Seagam, and I. B. Sanburn. The development work for the group has all been performed on the Homestake grant, which is located on the south side of Merritt creek, two and a half miles from the Lewes river. The valley of the creek at this point is 300 feet above the average level of the river, at the creek mouth, and the main workings of the property are about 150 feet above the creek bottom. There is a good grade for a road to this property, from the river, up Merritt creek.

The widest vein found on this property, and on which nearly all the development has been expended, is 6 ft. 6 ins. wide, where it outcrops on the surface. A drift has been driven on it, which, including several cross-cuts run off it, has an aggregate length of 155 feet. The vein in the drift has a width of from 12 to 55 inches, and is in the greenish schistose rocks near their contact with the granite formation. Besides this main vein, other stringers up to 10 inches wide were encountered in the drift and cross-cuts.

The formations along the face of the hill have been considerably shattered and faulted, causing the veins in the drift and elsewhere in the vicinity to be often broken, rendering the working of them somewhat difficult.

The main vein in the drift strikes about N. 83° E, and dips to the northwest at 45° to 55°. Outcropping along the face of the hill, and a few feet below the drift, is a connected series of elongated quartz lenses whose maximum width is 3 to 4 feet; which is traceable for over 200 feet, and strikes N. 42° W, the lenses usually dipping at 80° to 85° to the northeast.

Higher up the hill four other veins have been uncovered, having, where exposed, widths of 14 inches, 16 inches, 2 feet, and 3 ft. 6 ins., respectively.

The wider veins are often of a composite character; consisting of a zone of amphibolite, along the foliation planes of which, more or less quartz has been introduced. In the drift, where it is widest, the vein consists of a number of layers of schistose rock alternating with tabular masses of quartz, the two being in about equal amounts. In places, however, along this vein, and along others on this and neighbouring properties, the greater part of the quartz in a cross-section occurs in a single mass or lens; the lenses are, occasionally, connected, forming practically continuous veins for considerable distances.

An average surface sample from the 6 ft. 6 ins. of quartz above the drift was assayed, and gave: gold, 20 cents; silver—trace; copper, 0·28 per cent.

An average sample was also taken of a number of large pieces of the better grade of ore from the different surface exposures on the Homestake property. This assayed: gold, \$1; silver, 1·30 ounces; copper, 0·92 per cent.

The solid rock formations on the Homestake and neighbouring grants are nearly everywhere covered, and the finding of the quartz has been generally due to some such fortunate accident as the finding of particles of quartz attached to the roots of an overblown tree. Since quartz has been found at so many points, with little bedrock visible, it seems quite probable that a large number of veins would be exposed if the mantle of superficial materials could be removed.

1910

In 1910 no field work was done in Yukon Territory.

1911

Introductory Notes

In his Summary Report for 1911, page 4, the Director, Mr. R. W. Brock, includes the following notes on field work in Yukon Territory:

"Mr. D. D. Cairnes was engaged on the Yukon-Alaska boundary line between the Yukon and Porcupine Rivers.

"For the geological work in both Yukon and Alaska, a geological section to the Arctic Ocean is needed, and the Geological Surveys of the United States and Canada are co-operating in this work, Canada becoming responsible for the section along the boundary line from the Yukon to the Porcupine River, and the United States for the section from Porcupine River to the Arctic Ocean. The total length of the combined section will be about 340 miles.

"Returning from the field, Mr. Cairnes examined a number of quartz properties in the neighbourhood of Dawson."

The preliminary reports by D. D. Cairnes, published in the Summary Reports for 1911 and 1912 and dealing with his explorations along the Yukon-Alaska Boundary north of Yukon River, are not reprinted here as the information they contain was later published in Memoir No. 67 as a single complete volume, with maps, and a supply of this publication is still available. Only that part of Cairnes' report for 1911 describing 'Quartz Mining in the Klondike District' and including a note on Dublin Gulch and vicinity is reproduced here.

QUARTZ MINING IN THE KLONDIKE DISTRICT

by D. D. Cairnes

After completing the regular season's work along the 141st meridian* (the Yukon-Alaska boundary) a few days in September were spent in the examination of a number of the more promising quartz properties in the Klondike district, mainly in that portion of Dawson Mining district which is situated along and between Indian and Klondike rivers and their tributaries.

Considerable interest has of late been displayed concerning the quartz veins of the Klondike, and special efforts are being made to develop the lode mining of this district, in the hope that a revenue may eventually be derived from this source that will continue to foster the mining industry of this portion of Yukon when the placer deposits have become exhausted, which it is thought, however, will not be for many years to come.

Summary and Conclusions

Quartz veins are very plentiful in the schistose rocks of the Klondike district, and although the greater number of these deposits are small and

* For the results of this work see pp. 17-33 of this Summary Report.

non-persistent, still the aggregate amount of quartz is very great. Occasional very encouraging assays have been obtained, but with rare exceptions it is not even approximately known what average amounts of gold the deposits in the different localities contain. The quartz is practically all free-milling and is but slightly mineralized, the only metallic constituents apparent being pyrite, and rarely magnetite, chalcopyrite, galena, and native gold.

More systematic sampling and assaying should be conducted to obtain a fair general idea of the gold content of the quartz, and the various deposits should be more thoroughly prospected to ascertain their probably lateral and vertical extent. In case the results of these tests prove sufficiently encouraging, it would be particularly advantageous to have a stamp mill built at some convenient point capable of handling readily and quickly 5 or 10 ton samples from the various deposits of the district; in this manner claim owners could obtain sure and ready information concerning their properties. This is virtually the only way that reliable results can be obtained from these low-grade, free-milling deposits, as it is almost impossible to obtain perfectly satisfactory results from ordinary assay samples, and the expense of shipping small samples to outside points is practically prohibitive.

The Quartz Deposits

A great amount of quartz occurs in the old schistose rocks that are so extensively developed in the Klondike district, and in some localities it is in sufficient quantity to even constitute a considerable portion of the whole rock mass. The quartz occurs prevailingly in veins which exhibit considerable variety of form, and are as a rule small and non-persistent, but range in size from mere threads to masses several hundred feet in length but in most places less than 10 feet in thickness; one vein, however, on Yukon river below the mouth of Caribou creek, exceeds 30 feet in thickness.

The most common type of vein is lenticular in form, the individual lenticles measuring but a few inches in thickness and less than 50 feet in length; in places, however, individuals as much as 10 feet in thickness occur, but even these are rarely traceable for any considerable distances. The lenses in most places follow, in a general way at least, the strike of the schistosity of the containing rocks, but along their dips they frequently cut the wall-rocks at various angles.

Typical bedded or sheeted veins are also characteristic of some localities; in this type of deposit the quartz occurs interleaved with the folia of the schists, the individual quartz bands being generally but a few inches in thickness; in places such deposits occur in zones up to 10 feet or more in width that consist entirely of alternate quartz and schist lamellæ exhibiting a wide range of relative proportions.

Typical fissure veins were also noted, but on account of the decidedly schistose and fractured character of the enclosing rocks, these veins readily pass into the lenticular or sheeted types, due to the fact that the solutions from which the quartz was deposited, were naturally frequently diverted in whole or in part from the particular channels along which they might at any time be travelling, on account of the multitude of cleavage and fracture cracks which intersect these rocks, affording thus numerous routes for percolating waters. All types of veins are thus liable to bifurcate or branch out, and smaller veins frequently unite to form larger deposits. In places along lines of previous excessive fracturing, mineralized zones occur in which several of the vein types are represented; lenses, sheets, pockets, and various irregular deposits of quartz may be separated by and include varying amounts of wall-rock, and the whole be intersected by, or associated with numerous stringers and fissure veins of quartz.

A notable feature of some of the veins is the presence in them of occasional feldspar crystals indicating their relation to certain pegmatites in the vicinity. In this connexion Mr. McConnell says*: "A few examples of typical pegmatite veins or dykes occur in the district, and in one case, a coarse-grained pegmatite vein was observed to pass along its strike into a purely siliceous rock. The aqueo-igneous origin of the pegmatites, and their close genetic connexion with certain classes of quartz veins, maintained by various writers, is supported by the facts observed in the Klondike district."

The quartz veins are in most places but slightly mineralized; pyrite and more rarely magnetite occur in places in sufficient quantity to produce a reddish coloration on the exposed and oxidized portions of the veins, and in a few places the quartz contains particles of galena, chalcopyrite, and native gold.

The Economic Importance of Quartz

Often fair and occasionally even high assays are obtained, and in places the quartz shows native gold, but, except in possibly a very few instances, it is not known even approximately what average amounts of gold the quartz contains. From the various properties that have been examined, however, the gold that does occur is always either associated with metallic sulphides or is at or near the contact between the quartz and schists; in the latter case the gold is generally found in both vein material and wall-rock.

It would thus seem possible that some of the fractured zones that have become irregularly impregnated with quartz, may prove of greater value than the more clearly defined massive veins, since the former contain a greater area of contact-surfaces in the same volume or weight of material. However, the majority at least of the mineralized zones that have been examined, do not appear to be sufficiently persistent to allow of their containing sufficient quantities of pay-ore to make a mine; it is possible, nevertheless, that larger and more richly mineralized zones may yet be found. In a number of places several veins or mineralized zones which were noted in close proximity to each other could be worked conjointly. These would yield a considerable tonnage, and would become important producers if the bulk of the quartz will pay for milling. It is thought that, since the majority of the veins are non-persistent, the successful exploitation of the quartz of this district will largely depend on finding groups of veins or mineralized zones sufficiently close to allow of their being worked conjointly.

The deposits that have already been discovered in Klondike, in all probability represent but a small portion of the quartz that actually exists in the district, as bedrock is covered by superficial deposits in most places, except along the summits of the hills and ridges, and along the sides of the secondary valleys, where the bulk of the quartz occurs that has so far been found; other discoveries have been largely accidental and due frequently

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* McConnell, R. G. "Report on the Klondike gold fields": Ann. Rept., Geol. Surv., Canada, Vol. XIV, p. 63 B.

to placer operations. It is, therefore, probable, that future prospecting and development will disclose numerous deposits that are at present unknown.

More development should be performed, however, in connexion with the quartz deposits of the district that have been already discovered, with a view to ascertaining their extent, and more systematic sampling and assaying should be performed in order to determine within reasonable limits, at least, the average values of the materials they contain. It seems probable that at least the upper weathered and decomposed portions of a number of the deposits could be profitably milled, due to the fact that the district has not been glaciated, and a certain surface concentration of gold is to be expected, and in places is known to occur.

Prospectors and others interested in lode mining frequently do not sufficiently realize the importance of assays, and when these are made, in probably the majority of instances in Klondike district, they are from samples that are not representative of the deposits from which they are taken. Two reasons seem mainly to account for this condition: one is that it is not as convenient to have assays made in Yukon as in most mining districts, and moreover it is frequently realized how difficult it is to obtain really representative assay samples from free-milling deposits.

The most reliable and satisfactory results for such ores are obtained from mill tests of at least 5 or 10 ton lots. A sampling mill capable of making tests of 10 ton samples of the different quartz deposits of this district would greatly facilitate the development of the industry, and would stimulate prospecting throughout the district. With such a mill situated somewhere in the vicinity of Dawson, sufficient information could be obtained in a short time, possibly in one or two seasons, to demonstrate whether the Klondike has or has not a future in quartz. If these deposits are not profitably workable, the sooner this is known the better it will be for those owning, holding, and developing such properties; also if a number of deposits are sufficiently rich to become producers, the earlier this fact is established the greater will be the benefits that will accrue to the territory in general and to those most interested. In the meantime, however, it is important that more definite information be obtained concerning the extent and average value of the various deposits throughout the district.

Mining Properties

General Statement

Among the more promising quartz properties in the Klondike district, and those on which the most energy has been expended in development, are: the Lone Star group, near the head of Victoria gulch, a tributary of Bonanza creek; the Violet group, situated along the divide between Eldorado and Ophir creeks; the Mitchell group, on the divide between the heads of Hunker and Goldbottom creeks; the Lloyd group and neighbouring claims, situated along the divide between the heads of Green gulch and Caribou gulch, tributaries respectively of Sulphur and Dominion creeks; and several groups of claims on Bear creek near where joined by Lindow creek. Of these, the Lone Star was the only property on which any work, other than the necessary assessment duties, was being performed during the summer of 1911.

In addition to the above-mentioned properties, considerable enthusiasm has been aroused during the past two seasons over a number of claims staked on Dublin gulch, a tributary of Haggart creek which drains into the south fork of McQuesten river. This locality is not in the Dawson mining district, but is in the Duncan Creek mining district; it is, nevertheless, frequently spoken of as being in the general Klondike district and will be here so considered.

The Lone Star Group*

The Lone Star group is situated near the head of Victoria gulch, a tributary of Bonanza creek. This property is owned by a joint stock company with head office in Dawson and having a capitalization of $1,500,000; the president, Dr. Wm. Catto, as well as the secretary-treasurer, and the majority of the board of directors also reside in Dawson.

On these claims two main veins, or really one vein and a mineralized zone, have been discovered, which have been, by the owners, designated respectively the 'Corthay vein' and the 'Boulder lode'; these occur in much metamorphosed sericite and chloritic schists. The Boulder lode strikes N. 50° W.,** dips from 70° to 80° to the S.W., and is in most places at the surface from 3 to 10 feet in width, containing 1 foot to 7 feet of quartz. This 'lode' has been traced definitely along its outcrop for 400 feet, and quartz is exposed at various points in the same general line of strike for 600 feet farther, indicating that this zone may persist for this distance. The quartz occurs prevailingly in lenses, sheets, and irregular bodies ranging in size from those that are only microscopically observable to others 3 or 4 feet in thickness; these are interbanded or interfoliated with the schists, and generally agree with them in strike, but along their dips cut the planes of schistosity of the enclosing rock at various angles up to 90°. In places masses of practically solid quartz as much as 4 or 5 feet thick occur, but such a condition is rather exceptional. Numerous fissure veins or stringers less than 6 inches in thickness, intersect the main zone in various directions.

The Corthay vein strikes N. 14° W., has an almost perpendicular attitude, and where it has been explored is much more regular than the Boulder lode; this deposit also resembles more an ordinary compound fissure vein, and consists mainly of quartz which is in most places from 3 to 6 feet in thickness.

The quartz of both the Corthay vein and the Boulder lode is but slightly mineralized, the only metallic constituents that were noted being pyrite and native gold. The pyrite occurs as scattered particles or in small bunches, and is in sufficient amount in places to give the quartz a rusty appearance where weathered. The native gold occurs mainly as occasional grains and nuggets both in the quartz and wall-rock, but prevailingly near their contact, and is in places quite well crystallized.

An open-cut about 70 feet long, 10 feet wide, and having an average depth of approximately 15 feet, as well as 8 or 10 smaller surface cuts or pits have been dug at intervals along the strike of the Boulder lode. A cross-cut tunnel 310 feet long has also been driven, from which, when examined in September, 1911, about 40 feet of drifting had been run on the Boulder lode which at this depth of approximately 60 feet was much narrower than at the surface and contained in most places less than $2\frac{1}{2}$ feet

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* McConnell, R. G. "Report on the Klondike gold fields": Ann. Rept., Geol. Surv., Canada, Vol. XIV, pp. 64 B-65 B.

** All bearings given in this report are astronomic or true. The magnetic declination in the Klondike district is in most places 35° east.

of quartz. A vertical shaft has been sunk through the schists and tapped the Corthay vein at a depth of 60 feet where the quartz was about 4 feet thick. Another shaft 40 feet deep has been sunk on the Corthay vein and was connected with a drift from the tunnel by a 30-foot upraise; a drift 70 feet long was also run from the bottom of this shaft.

A four-stamp Joshua Hendry mill has been erected on this property, and a gravity tramway 3,500 feet long has been constructed to convey the ore from the workings to the mill on the creek about 900 feet below. A power line 4 miles long was about completed in September, which was to convey power to the mill from the power line of the Northern Light and Power Company on Bonanza creek, the cost of the power to be at the rate of three cents per horse-power.

Miners working on this property and in the vicinity receive $4 per day (10 hours) and board.

The manager of the Lone Star group claims to be able to mine and mill the ore from this property for $3.50 per ton. It is not known what average amounts of gold the quartz and adjoining rock there contain, but a number of promising assay returns have been received and the tests that have been made indicate that at least the somewhat decomposed superficial portion of the Boulder lode and possibly of the Corthay vein as well should pay to mill. No definite information was obtained concerning the remaining portions of the deposits.

The Violet Group*

The Violet group is situated on the divide between Eldorado and Ophir creeks, about 5 miles from Grand Forks, and consists of four claims and a fraction, all of which are Crown granted. It is claimed that $60,000 has been spent in developing this property which, however, was sold by public auction in September, 1910, and acquired by the present owner, Mr. H. H. Honen.

Three veins are reported to have been discovered on this property, but the bulk of the work has been done on one of these which strikes in a southeasterly direction with the enclosing schists, but dips across them. This vein is in most places from 3 to 6 feet in thickness, and the quartz composing it is crystalline and contains considerable reddish feldspar giving it a pegmatitic appearance. The quartz contains considerable iron which near the surface weathers and gives the vein a rusty appearance; particles of galena were also noted. It is not known what amounts of gold this vein contains but it is stated to average $10 to $11 per ton.

Three shafts, respectively 55 feet, 35 feet, and 150 feet in depth have been sunk on the property, and 300 feet of drifts have been driven; in addition, one open-cut 50 by 12 by 15 feet approximately, and a number of smaller cuts have been dug.

The Mitchell Group

The Mitchell group is situated on the divide between the heads of Hunker and Goldbottom creeks, and consists of about 27 claims which are owned by Mrs. Margaret J. Mitchell.

A number of quartz veins occur on this property, but as the surface of

* McConnell, R. G. "Report on the Klondike gold fields": Ann. Rept. Geol. Surv., Canada, Vol. XIV, p. 65 B.

the ridge on which these have mainly been discovered is in most places covered with superficial materials, it is not known either how many veins may be present, nor even how many veins the known occurrence of quartz represent, as considerable stretches of bedrock are still covered between the different exposures. Quartz occurs in a number of small cuts or trenches more or less in alignment, that have been made on one part of the property at intervals throughout a distance of about 2,000 feet, yet this by no means proves that the quartz all belongs to the same vein; in places, trenches were sunk to bedrock across the supposed line of strike of this vein, and no quartz was encountered; and further, the exposures themselves are, in places, decidedly lenticular in form. For 600 to 800 feet, however, quartz has been found along a N. 5° W. direction wherever bedrock has been exposed to view, which is at frequent intervals; it would thus seem that for this distance either a fairly regular fissure vein or a nearly connected line of quartz lenses occurs. Other parallel lines of exposures were also noted, indicating that at least 3 or 4 veins and possibly many more than this number occur.

The quartz is all deposited in sericite schist, and whenever contacts between the quartz and wall-rock were noted the quartz cuts the schist folia along both dip and strike. The veins range from a few inches to 7 or 8 feet, but are in most places from 2 to 4 feet in thickness; the quartz generally contains almost no metallic constituents, but in places exhibits considerable disseminated pyrite which causes weathered surfaces to have a rusty appearance. A few particles of galena and native gold were also noted.

Only a few samples were taken from this property, but the results obtained from the analysis of these few, all indicate that the white unmineralized quartz rarely carries more than traces of gold, which mineral almost invariably occurs either associated with the metallic sulphides or near the contact of the quartz and schist, and in either material.

The development work performed on this property consists mainly of a number of open-cuts, shallow trenches, and pits, and also a shaft 80 feet deep, from which a 50-foot drift has been driven. The shaft was filled with water when visited, but a grab sample was taken from the dump, which assayed $5 in gold per ton*; this is the highest assay obtained from the various samples taken by the writer from the Mitchell group, although much higher returns are believed to have been received from other samples taken previously. It, therefore, appears that, although the aggregate amount of quartz on this group of claims is considerable, by no means all the material will pay for treatment. The various veins should thus all be systematically sampled, to obtain an estimate of their probable average values, and to determine approximately the veins and portions of these that will pay for mining and treatment.

The Lloyd Group

The Lloyd group is situated at the head of Green and Caribou gulches, tributaries respectively of Sulphur and Dominion creeks, and consists of 17 Crown-granted claims owned by Messrs. James Lloyd, J. A. Segbers, and Wm. Nolan.

* All the samples that were taken by the writer from the various claims in the Klondike district during the past season, were assayed by the Mines Branch of the Department of Mines, Ottawa.

A number of exposures of quartz 2 to 6 feet in width occur on this property, but in only a few places could the thicknesses of the veins, and their relations to the wall-rocks be determined; the other known occurrences of quartz were either still more or less covered with superficial materials, or the various shafts, cuts, etc., that had at one time exposed the veins, contained considerable water or other materials that had drained or fallen in since the work was performed. One vein, however, was well exposed in a 25-foot shaft near the cabin; this deposit has an average thickness of about 3 feet, strikes N. 58° W., dips at angles of 60° to 70° to the N.E., and cuts across the foliation planes of the schist wall-rock with every appearance, in the shaft at least, of being a typical regular fissure vein. The wall-rocks everywhere observed are sericitic or chloritic schists.

The quartz outcrops on this property are in most places from 2 to 3 feet in thickness, and represent at least 3 or 4 veins and possibly more. In different portions of the claims exposures of quartz, approximately in alignment, were noted at various intervals extending throughout distances of several hundred feet, but until more development has been performed, it will be impossible to decide whether these lines of exposures each represent one continuous vein or several more or less connected lense-shaped deposits such as characterize the schistose rocks of that district.

The quartz is characteristically white and generally but slightly mineralized; however, in some places, the veins carry considerable disseminated pyrite which where oxidized gives the quartz a reddish iron-stained appearance; occasional particles of galena were also noted.

Concerning the average gold content of the quartz, but little is known. The writer took only three samples from the different veins of the Lloyd group, and all yielded merely traces of gold. However, one of the owners of these claims had what he considered to be an average sample of one of the veins tested during the time I was in Dawson, and this gave $10.60 in gold to the ton; and other still higher assays are believed to have been obtained at different times. In this connexion, however, it is to be remembered, as previously mentioned, how extremely difficult it is to get satisfactory results from assay samples of low grade free-milling ores; the samples taken by the writer may not be at all representative of the veins from which they were taken. To obtain reliable information concerning such ores, either a great number of assays must be taken, or mill tests must be made.

Considerable prospecting work has been performed upon this group of claims, mainly as follows: about 10 shafts having an average depth of approximately 30 feet have been sunk, the deepest of these being down 56 feet when visited in September; in addition a number of open-cuts and trenches have been dug.

Bear Creek

A number of quartz claims, probably 30 or 40 in all, owned by John Nicholas and others, have been located on the right limit of Bear creek near the junction of this stream with Lindow creek. The schistose bedrock at different points on these claims, contains deposits of quartz impregnated with more or less pyrite, and in places showing particles of native gold that is occasionally quite crystalline. It is not known what average amounts of gold the veins in this vicinity contain, but it is claimed that a number of promising results have been received.

Dublin Gulch and Vicinity

Dublin gulch is a tributary of Haggart creek which drains into the south fork of McQuesten river. A considerable number of claims have been located on Dublin gulch and in that vicinity, extending throughout a belt about 8 miles long. This locality has not been visited by the writer, but some quartz deposits near Dublin gulch were examined and reported upon by Mr. Joseph Keele* of this department in 1904.

During the past two seasons, especially, a number of discoveries that are reported to be very promising have been made in the Dublin Gulch locality, with the result that a considerable renewal of activities and enthusiasm has been evidenced; old claims have been relocated, new claims have been staked, and prospecting has received a decided stimulus. Some of the main claim holders in the district are Dr. Wm. Catte, Mr. Jack Stewart, and Messrs. Fisher and Sprague.

While in Dawson, the writer was shown a large number of specimens of the ores from Dublin gulch and the surrounding district; these all consisted mainly of quartz carrying varying quantities of mispickel (arsenopyrite or arsenical iron pyrite) and occasional particles of pyrite; the quartz in places was coated with a yellow ferric arsenate. A few typical samples were selected and an average assay has been made from these, which yields 3·98 ounces of gold, or $79.60 per ton.

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* Keele, J. "The Duncan Creek mining district": Ann. Rept. Geol. Surv., Canada, Vol. XVI, 1904, pp. 38A-39A.

1912

Introductory Note

In his Summary Report for 1912, page 2, the Director, Mr. R. W. Brock, includes the following note on field work in Yukon Territory:

"Mr. D. D. Cairnes completed the geological section along the 141st meridian between the Yukon and Porcupine Rivers. This is part of a geological section across the northern Cordillera undertaken in co-operation with the United States Geological Survey, which assumed responsibility for that portion between the Porcupine and the Arctic Ocean. This section is being made as reference section for the correlation of the geological formations of Alaska and the Yukon district. The most interesting result of Mr. Cairnes' work is the recognition of the Cambrian formation in this section, which consists of dominantly sedimentary rocks of Mesozoic, Palæozoic, and Precambrian age; the entire Palæozoic appears to be represented."

The preliminary report by D. D. Cairnes, which followed in the Summary Report for 1912, and which dealt with his explorations along the Yukon-Alaska Boundary north of Yukon River for that year, has not been reprinted as the information it contains was later published with that of the Summary Report of 1911 in Memoir No. 67 as a single complete volume, with maps, and a supply of this publication is still available.

1913

Introductory Note

In his Summary Report for 1913, page 4, Mr. R. W. Brock, Deputy Minister, Department of Mines, provides the following note on field work in Yukon Territory:

"Mr. D. D. Cairnes conducted a geological reconnaissance along the Alaskan-Yukon boundary line in the Upper White River district, where native copper occurs in economic importance at one point. During the season the Chisana placer gold district in the adjoining portion of Alaska attracted attention; as the conditions are similar on both sides of the line, it is hoped that placers may be located on the Canadian side."

The preliminary report by D. D. Cairnes published in the Summary Report for 1911 and 1912 dealing with his exploration in the Upper White River district is not reprinted here, as the information it contains was later published in Memoir No. 50, of which a supply is available.

1914

Introductory Note

In his Summary Report for 1914, page 3, R. G. McConnell, Deputy Minister, Department of Mines, submits the following note on field work in Yukon:

"D. D. Cairnes spent the summer in general exploratory work in the southwestern part of Yukon Territory. A large part of the area was little known either geologically or geographically and, since placer gold, gold ores, copper ores and lignite were known to occur there, it was considered important that its mineral resources generally should be reported on. Mr. Cairnes made a number of traverses across the district and examined most of the creeks."

EXPLORATION IN SOUTHWESTERN YUKON

by D. D. Cairnes

Introduction

Reasons for Work

The summer of 1914 was spent by the writer in conducting general exploratory work throughout the southwestern portion of Yukon Territory north of the latitude of Whitehorse. The work was undertaken for the purpose of obtaining as much information as possible relative to this extensive region, concerning the greater part of which very little was known of a geological or even, in places, of a geographical nature.

Placer gold has been mined on a number of creeks in Kluane district since 1903, and has also been produced in small quantities from Nansen district since 1910, having been originally discovered there in 1899. Deposits of lignite were also known to occur in Kluane district, and placer gold, gold ores, copper ores, lignite, and other minerals were reported to have been found at a number of other points throughout this general region. Nevertheless, although this section of Yukon would thus seem to possess considerable promise of future economic importance, almost the only authentic information available concerning it was the result of the work of Mr. R. G. McConnell who spent the summers of 1903 and 1904 in Kluane district[1] and along certain headwaters of White river[2], and even these investigated areas include only a very small portion of Southwestern Yukon. Moreover, since 1904 practically no information at all had been obtained concerning the entire region here under consideration, until 1913 when the writer devoted part of the summer to the examination of Upper White River district,[3] which, however, also occupies only a small section of the extreme western part of this wide, largely unexplored tract.

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[1] McConnell, R. G., "Headwaters of White River": Geol. Surv., Canada, Sum. Rept. for 1905, pp. 19-26.

[2] McConnell, R. G., "The Kluane Mining district": Geol. Surv., Canada, Sum. Rept. for 1904, pp. 1A-18A.

[3] Cairnes, D. D., "Upper White River district": Geol. Surv., Canada, Sum. Rept. for 1913. "Upper White River district": Geol. Surv., Canada, Mem. No. 50, 1914.

It seemed very desirable, therefore, and even urgent that as much economic and scientific data as possible should be obtained concerning this region, particularly since placer gold in economically important amounts had been discovered during the summer of 1913 in Chisana district*, Alaska, not more than 30 miles west of the Yukon-Alaska International Boundary line. As a result of the finding of gold in Chisana, a large number of prospectors, miners, and others had passed through or visited the adjoining portions of Yukon, and many of these prospectors had either remained in Yukon or had returned there, and were reported to have made important discoveries of valuable minerals in various localities. Accordingly the writer was instructed to spend the field season of 1914 in Southwestern Yukon, and to obtain as much general information as possible concerning this region, special attention to be given to the occurrences of economically important mineral deposits.

Work Performed

The greater part of the summer was devoted to traversing, although some areal mapping was also performed. The different traverses were located so as to crosscut the major geological and physiographic features or terranes of Southwestern Yukon along a number of somewhat widely separated lines, and were so arranged as to connect with or pass through the leading mining areas. It was hoped to obtain in this way the greatest amount of valuable information concerning this region, in the shortest possible time.

Commencing at Whitehorse, a traverse was run along the wagon road to Kluane, a distance of 150 miles, and the geology was mapped along the route for a width of from 2 to 6 miles, the mapped portion being, however, in most places from 3 to 4 miles wide. Along this traverse, as in the case of all the other traverses this season, the width to which the geology was mapped on either side, was conditioned largely by the accessibility of rock outcrops.

From Kluane, a traverse was extended to Nansen creek, a distance of 103 miles. Trails were followed where they occurred, but for the greater part of this distance no trails, or at best, only poorly defined Indian trails were available. The geology was mapped along the line of travel for a width of from 3 to 6 miles, the mapped strip being in most places, however, about 4 miles wide. During this trip the gold-bearing gravels on Ruby creek and on Fourth-of-July creek and its tributaries, were examined. Also an area 10 miles long, by 7½ miles wide, including Nansen creek, was geologically mapped. This area is here designated Nansen district, and includes all the known gold-bearing creeks in that vicinity.

Returning again to Kluane, a traverse was made along the upper (south) end of Lake Kluane to near the north end of the lake, and was from there continued up Burwash creek, down Wade creek to Donjek river, down the Donjek and across this river to Wolverine creek, up Wolverine creek to its head, thence down Harris creek to Generc river, across the river, and from there to Canyon City, a distance from Kluane of 132 miles. A blazed trail was followed the greater part of this distance. Between

* Cairnes, D. D., "The Chisana Gold Fields": *Jour. Can. Min. Inst.*, vol. xvii, 1914, pp. 33-64.

Kluane and Canyon City, the placer gold gravels of Bullion, Sheep, Burwash, and Arch creeks were examined; the lignite deposits at the head of Sheep creek and between the upper portions of Burwash creek and a tributary of Duke river were investigated; and the copper deposits along Quill creek, and between this stream and Burwash creek were visited.

After arriving in Canyon City, which is situated near the southern end of Upper White River district, camp was moved to near the mouth of Pan creek. The gold-bearing gravels on this stream and on adjoining creeks were then examined, and afterwards about a week was devoted to completing the geological mapping in the northern portion of Upper White River district. A number of hills or mountains within this district were not examined the previous summer (1913) owing to lack of time, as the writer had to leave the field early in August to act as guide on certain of the excursions of the International Geological Congress.

Having completed the geological mapping of Upper White River district, a traverse was commenced at the mouth of Sanpete creek, and extended to the mouth of Coffee creek on Yukon river, a distance of 91 miles. Throughout this distance, the geology was mapped for a width of from 2 to 4 miles, the mapped strip, in most places, being, however, about 3 miles wide.

Altogether about 476 miles were traversed, and as the geology was mapped along the routes travelled for an average width of about 4 miles, approximately 1,900 square miles were geologically mapped along these traverse lines; in addition, the topography was also approximately sketched along both sides of the travelled routes. Also, Nansen district with an area of over 75 square miles, as well as portions of the northern part of Upper White River district, were mapped, making a total of about 2,100 square miles of geological mapping. Further, the gold-bearing gravels, copper deposits, lignite seams, and other occurrences of economically important minerals were examined throughout Kluane and Nansen districts, as well as in portions of Upper White River district.

In traversing, the distances were estimated by means of an odometer or measuring wheel. The routes were plotted, and the topography on either side of the traverse lines was sketched on a plane-table sketch board. Sun azimuths were taken morning and afternoon to correct the magnetic readings of the compass needle on the sketch board. The work was plotted in the field on a scale of $\frac{1}{192,000}$ or about 3 miles to the inch. In Nansen district, the base lines on the various creeks, run by H. G. Dickson, D.L.S., of Whitehorse, Yukon, were used as a base, and these traverses were extended, where it was found necessary, to complete a drainage map of the area, on which to plot the geology.

Acknowledgments

The writer was assisted in his work in every way possible by all the prospectors, miners, and others with whom he came in contact, a cordial co-operation being everywhere extended, for which he wishes to express his sincere gratitude. Particular thanks are due to Mr. A. D. MacLennan, Mining Recorder of Kluane mining district, who supplied a great amount of valuable information from his office, and accompanied the writer's party as far as Fourth-of-July and Ruby creeks, to facilitate the work of investigation in the portions of Kluane district with which he was most familiar.

The writer's assistants for the season were F. J. Barlow, Robert Bartlett, and E. C. Annes. Mr. Barlow assisted with the geological work, while the Messrs. Bartlett and Annes devoted their time to the topography. All performed the duties assigned them in a perfectly satisfactory and highly efficient manner.

Extent of Report

In this summary report the more salient features of economic interest will be described and the general geology of certain areas or localities will be briefly outlined, where such an outline is necessary to a clear understanding of the importance of the mineral deposits. It is the intention of the department later to publish a memoir in which the writer will give all the information available concerning the southwestern portion of Yukon, including detailed descriptions of the geology, mineral, and other natural resources.

Mineral Resources

The mineral resources of the portion of Southwestern Yukon here under consideration include mainly, so far as is known at present, placer gold, copper deposits, and coal. Quartz veins containing gold, silver, and, in places, copper, occur in certain localities, but no veins have yet been discovered containing these minerals in sufficient quantities to be of present economic value.

Of these resources, placer gold is of the most immediate economic importance, leaving out of consideration the copper deposits of the Whitehorse belt which were not examined by the writer during the past summer, but which are included in the region represented by the accompanying map. In addition to the occurrences in the Whitehorse belt, deposits carrying copper minerals have been found in a number of other localities within this portion of Southwestern Yukon, but none have so far been discovered that could be exploited under existing conditions. Extensive deposits of coal (lignite) occur in Kluane district and vicinity, and constitute a valuable future asset, but at present there is only a very small local consumption, and owing to its inaccessibility, it is not at present shipped to other points.

Placer Gold

Distribution

Placer gold has, up to the present, been found mainly in Kluane and Nansen districts, though promising discoveries have been made on two or three creeks in Upper White River district; and at a number of isolated, widely separated points, other finds have been made, some of which may prove to be of economic value.

On Koidern river* which joins White river on the right bank** about 18 miles below the mouth of Generc river, important discoveries of gold-bearing gravels are reported to have been made. On Albert creek, which empties into the northern end of Lake Sekulmun, a number of claims have been located, and both Indians and white men stated to the writer, that they had found very encouraging prospects on this stream. A number of men have

* Also known as Lake creek.

** In Yukon, the terms right limit and left limit are commonly used to designate the right bank or left bank of a stream, meaning the right or left side, respectively, as observed by a person facing downstream.

recently been engaged in prospecting on Klotassin creek, an important tributary of Donjek river, and on certain of its branches, and in some cases, report quite satisfactory results. On several of the upper tributaries of Nisling river, in addition to the creeks included in Nansen district, prospecting has been carried on during the past two years with encouraging results. On Coffee creek prospecting work was performed during the winter of 1913-14, but it is believed that no deposits of gravels that would pay to work were found.

So far as the writer's information goes, only in Kluane and Nansen districts, are gravels known to have been found as yet that can be profitably exploited. Throughout a large portion of this extensive region, nevertheless, the geological conditions are particularly favourable for the accumulation of valuable deposits of gold-bearing gravels, the bedrock formation over wide areas, consisting dominantly of the older schists similar to those so extensively developed in Klondike and Sixtymile districts. Further, the northeastern part of the region lies entirely outside of the glaciated zone. This feature of non-glaciation is important since it means that wherever gold has been concentrated in the stream gravels, it probably remains undisturbed, and that the gold-bearing gravels are not overlain by vast accumulations of glacial detritus as they are farther to the west and south. In the Klondike, these two conditions appear to be mainly accountable for the richness of the stream gravels; in the first place, the bedrock consists dominantly of the old, highly mineralized schists which originally carried the gold; and in the second place the district has not been glaciated.

In spite of the fact, however, that Southwestern Yukon would thus seem to be geologically so favourable for the occurrence of placer gold, as well as other minerals, very little prospecting has been done except in a few scattered localities, and the mineral resources remain almost entirely unexplored. It is quite possible or even probable, therefore, that important finds of placer gold will yet be found in this general section of Yukon Territory, and it would be well in prospecting, that particular attention should be given to the northeastern unglaciated portion of the district.

Kluane District

General Description. Kluane district is situated in the western portion of Southwestern Yukon, and lies along the northeastern slopes of the St. Elias range of mountains, between latitudes 60°50′ and 61°40′. It is so named because it includes Kluane lake, a body of water over 35 miles in length, which lies near the centre of the district.

Attention was first directed to Kluane district as a mining area during the summer of 1903, when placer gold was found to occur at a number of points. Discovery claim on Fourth-of-July creek was staked on July 4, of that year, by Dawson Charlie, a well-known Indian of Carcross. During the remainder of 1903 and the summer of 1904, a great number of placer claims were located, the majority of the creeks throughout the district being staked; and from that time to the present, the district has continued to produce placer gold. The output, however, has always been small, and the number of men engaged in placer mining since 1904, has decreased yearly.

The present status of the placer mining industry in Kluane mining district, is summarized in the report of Mr. A. D. MacLennan, Mining Recorder, who writes of it in his annual report for the year ending April 30, 1914, as follows:

"Seventy-one renewal grants and twenty-five relocation grants were issued during the year. Actual mining reached its lowest ebb during the past year. The season was unfavourable for much successful mining.

"On Burwash, Sheep, and Bullion creeks, the unusually high water caused considerable damage to mining outfits, and by the time this damage was repaired and work resumed, the stampede to the new placer camp in Chisana, Alaska, attracted the miners of Kluane district. The stampede to Chisana, however, brought a number of miners and prospectors through Kluane district, and of these a number remained, and are now prospecting on different creeks of the district."

Thus, throughout the entire Kluane mining district, only 96 placer claims were held on April 30, 1914, and very few locations were made during the summer.

For a description of the Kluane mining district, including an account of the mineral resources, the general geology, the original discoveries, and of the developments until and including 1904, the reader is referred to Mr. McConnell's report on the district.[1]

Geologically, Kluane district is divisible into a northeastern and a southwestern part, lying on opposite sides of Kluane lake, and nearly equal in areal extent. The northeastern division is situated within the Yukon plateau physiographic province, and is underlain dominantly by mica and quartz-mica schists which range in character from finely-textured and highly schistose rocks, to coarsely textured members having in places a decided gneissoid appearance. These schists belong to the Yukon group[2] which includes the oldest rocks known to occur in Yukon or Alaska, and are thought to be of Pre-Cambrian age. This group of rocks as developed in Kluane district has been locally named by Mr. McConnell, the Kluane Schists[3]. These schists have been invaded by granitic intrusives which are extensively developed in places, and are believed to be of Jurassic or Cretaceous age.

The southwestern portion of Kluane district lies along the inner or landward edge of the St. Elias range, and includes rocks ranging in age from probably Pre-Cambrian to Tertiary. Of the rocks exposed between Bullion creek and the lower (northern) end of Kluane lake, certain of those outcropping along Bullion creek are believed to be the oldest. They include mainly phyllites, cherts, and limestones, and are thought to belong to the Tindir group[2] which is probably of Pre-Cambrian age. Overlying these rocks are several hundred feet of calcareous, argillaceous, and arenaceous sediments which are known to range in age from Silurian to Triassic, and may include pre-Silurian members and post-Triassic Mesozoic beds. These sediments have been extensively invaded in places by granitic intrusives, and have also been pierced and overlain by a group of basic to semi-basic igneous rocks, including mainly andesites, diorites, diabases, and basalts. These igneous members appear to be mainly of Jurassic or Cretaceous age, but some may be as old as Carboniferous. All these older rocks are overlain

[1] McConnell, R. G., "The Kluane Mining district": Geol. Surv., Canada, Sum. Rept. for 1904, pp. 1A-18A.

[2] Cairnes, D. D., "Geological section along the Yukon-Alaska Boundary line between Yukon and Porcupine rivers": Bull. Geol. Soc. Amer., vol. 25, 1914, pp. 184-187, and "The Yukon-Alaska International Boundary between Porcupine and Yukon rivers": Geol. Surv., Canada, Memoir No. 67, 1914, pp. 38-44.

[3] McConnell, R. G., op. cit., pp. 4A-6A.

in places by a thick series of Tertiary lignite-bearing beds which locally contain intercalated tuffs. The rocks of this Tertiary series are in turn invaded and overlain by basic to semi-basic lavas and associated pyroclastics, which are mainly of Tertiary age, but may include some Pleistocene members.

The entire Kluane district has been extensively glaciated, and the valleys are floored almost everywhere with boulder-clay, gravels, silts, and morainal accumulations, which are in places several hundred feet in thickness.

The creeks of Kluane district fall naturally into two groups: those of the northeastern and those of the southwestern portions of the district. The southwestern creeks head in the St. Elias range and drain by Kluane, Donjek, and Yukon rivers into Bering sea. The northeastern streams traverse the western or southwestern edge of the Yukon plateau and most of them head in the Ruby range; they drain either into Kluane lake and thence to Bering sea, or join the headwaters of Alsek river flowing to the Pacific ocean. The creeks of each group possess geologically many common characteristics but the members of each group differ in a number of fundamental respects, from the members of the other group.

The principal gold-bearing creeks of the northeastern group include Fourth-of-July creek with its tributaries, Ruby creek, and Gladstone creek. Fourth-of-July creek, Ruby creek, and the lower gold-bearing portion of Gladstone creek, flow in depressions cut through the old Kluane Schists. The valley bottoms, except near the heads of the streams, are deeply floored in most places with glacial accumulations, mainly with boulder clay, through which the present streams are entrenching their channels. The pre-Glacial channels are thus in most places buried under glacial deposits and lie below the levels of the present streams. The gold that has been obtained, therefore, has been mainly derived from the recent gravels which overlie the boulder-clay, the 'clay bedrock' of the miners, the buried pre-Glacial channels having nowhere as yet been found. On the upper portion of Ruby creek, however, some gold has been derived from the gravels of the present stream where they lie on the schist bedrock.

The most important gold producing streams in the southwestern portion of the district are Bullion creek, Sheep creek, and Burwash creek with its tributary Tetamagouche creek. Some gold has also been obtained from Arch creek, a tributary of Donjek river, but as this stream is isolated from the other gold-bearing creeks of the district, it will be described separately.

The bedrock of Bullion, Sheep, and Burwash creeks, ranges in age from Pre-Cambrian (?) or lower Palæozoic to Tertiary, both sedimentary and igneous members occurring. The old channels on these streams have been deeply buried under accumulations of boulder-clay and other glacial detritus, but the present streams, particularly in the lower portions of their valleys, have lowered their channels through the glacial accumulations, and have eroded deep canyon-like channels in the underlying bedrock. Thus, except along the uppermost portions of these streams, the old pre-Glacial channels have either been destroyed by the present streams or lie to one side of them and at various elevations above them. This is in decided contrast to the streams in the northeastern portion of the district, where all the old channels in the lower portions of the creek valleys are below the levels of the present streams.

Placer mining operations in the southwestern portion of Kluane district, have so far been almost entirely confined to the recent gravels that have accumulated on the bedrock formations of the different creeks. The positions of the old channels are in places quite evident, and sections of them are at certain points plainly in view along the valley sides; but owing to the great expense and time involved for their exploration, these channels remain as yet practically unexplored.

Throughout Kluane district, the bulk of the placer gold was originally concentrated in the old pre-Glacial channels which are now in most places deeply buried, and a great part of it may be still there. However, to determine the position of these old channels and to prospect them, means a large outlay of time and capital, and there is no certainty that at any particular point the old gravels have not been swept away by the ice, and their gold contents scattered.

Coarse gold has also been found on a number of other streams, but not, apparently, in sufficient quantities to pay for working. On Cultus creek some prospecting has recently been done, and on an unnamed tributary joining that stream on its left bank, gold is reported to have been found in encouraging amounts. Prospects have also been found on Printers (New Zealand), McKinley, and Dixie creeks, and some work has been done on them, in places with fairly encouraging results. It has been reported also that gold has recently been discovered on some of the upper tributaries of Kluane river.

Ruby Creek. Ruby creek heads in the summit of Ruby range, and flows southwestward into Jarvis river after a course of 8 or 9 miles. It is a steep mountain stream with a large volume of water in spring and early summer. As the snows in the upper regions disappear, however, the amount of water gradually dwindles and in late summer is reduced to about 200 miner's inches. From its head to the point where it joins the valley of Jarvis river, Ruby creek occupies a narrow, deep, steep-walled depression from 3,000 to 4,000 feet in depth, cut down through the old Kluane Schists. The valley is deeply floored with boulder-clay nearly to its head; and in the vicinity of Jarvis river the clay is overlain by extensive deposits of glacial silts. From about claim No. 21 above Discovery claim, to its head, Ruby creek has sunk its channel through the boulder-clay, and has eroded a rock canyon with abrupt walls 10 to 30 feet in height in the underlying schists. In places along this upper portion of the stream's course, the grade is so steep—occasionally exceeding 400 feet to the mile—that even the recent gravels have been washed away and the bedrock exposed. Below claim No. 21, the stream with its gravels overlies the boulder-clay, and although several shafts have been sunk along this portion of the creek, none have succeeded in reaching bedrock. Upstream from No. 21 above Discovery, bedrock is seldom more than 10 feet below the creek bed, although in places it is as much as 15 feet; below No. 21 it drops away suddenly and on No. 15 above Discovery, a shaft 68 feet deep failed to get through the boulder-clay. It would seem quite possible therefore that the old pre-Glacial channel crosses the present channel just below No. 21 above Discovery, and that above this point it lies to one side of the present channel.

Mining operations have been confined to the portion of the creek above No. 20 above Discovery, and the gold that has been taken from Ruby creek has practically all been obtained between the mouth of Little Ruby and No. 20 above Discovery, a distance of about three-quarters of a mile, the gold being very unevenly distributed throughout the stream gravels. The wash along this portion of the creek represents, to a considerable extent, a residue or concentrate from the boulder-clay, and consists mainly of flat pebbles and angular slabs of schist, with occasional large granite boulders, and a few quartz pebbles and boulders.

The total gold production of Ruby creek is probably between $6,000 and $8,000. The gold is coarse, rough, and occasionally crystalline, and has been derived from the underlying Kluane Schists and their contained quartz veins.

Unless the old channel is found and proved to contain rich gold-bearing gravels, not much more gold is to be expected from this creek, as the body of recent gravels is small and has not proved to be high grade. The old channel might be prospected for either by drifting in on bedrock above No. 21 above Discovery, or by sinking below No. 21, and drifting along on bedrock. Two drifts have already been driven in on the right bank of Ruby creek above No. 21 above Discovery. They follow the nearly flat surface of the bedrock, in a direction about at right angles to the general course of the stream. These drifts were caved in when seen by the writer; but it was stated by Mr. MacLennan that each is over 100 feet long, and that the surface of the bedrock is smooth and level, as might be expected in the case of the bottom of a depression planated by ice. Although there is no certainty of finding gold anywhere under the boulder-clay, as the stream gravels of the old channels may have been swept away during the glacial period, the chances of important discoveries on Ruby creek are favourable, and would seem to warrant a trial. There is little or no chance of finding gold in paying quantities along the creek, below the point where it enters the valley of Jarvis river, as there the gravels of the pre-Glacial channel have undoubtedly been scattered by ice which formerly moved through the Jarvis River valley.

*Fourth-of-July Creek and Tributaries**. Fourth-of-July creek is also a tributary of Jarvis river, but is a much larger stream than Ruby creek, its flowage in early summer amounting to several thousand miner's inches; it also differs from Ruby creek in dividing up into several branches after entering the mountains. The creek has also cut a wide, deep valley back into the Ruby range, and its various branches including Snyder, Alie, and Twelfth-of-July creeks also occupy steep-walled depressions, incised deep in the southern slope of the mountains. All these depressions are typically U-shaped, and their walls are planated and smoothed from the effects of intense valley glaciation which extends practically to the summits on either side. Both the creek and its tributaries, throughout almost their entire courses, cut the Kluane Schists. In places, however, greenstones and granitic intrusives are encountered, and on Larose creek the granitic rocks are quite extensively developed.

The valley of the Fourth-of-July creek is floored with boulder-clay to above the mouth of Snyder creek, and near the edge of the valley of Jarvis river the boulder-clay is in turn overlain by considerable thicknesses of glacial silts—some sands and gravels being also included. From a point a short distance above the mouth of Snyder creek, upstream to near its head, the boulder-clay has been largely removed and the schistose bedrock is exposed. The present stream with its recent gravels, overlies the boulder-clay from about three-quarters of a mile above the mouth of Snyder creek

* McConnell, R. G., op. cit., p. 12A.

to the canyon which occurs near the edge of Jarvis River valley. On both sides of the stream between these points, the valley is deeply floored with boulder-clay. At a few points, however, small schist outcrops occur along the sides of the creek and only a few feet above the water.

A number of claims are still held on Fourth-of-July creek, but during the past summer (1914) little work was done other than representation work to hold the ground. Shafts have been sunk in the valley deposits at various times, with a view to reaching bedrock, one of these shafts being approximately 70 feet in depth, but the bottom of the boulder-clay and associated deposits was nowhere reached. In most cases the shafts are believed to have been abandoned owing to the amount of water encountered. Even in winter the ground along the creek is not deeply frozen—in most places to a depth of only about 5 to 10 feet, but at some points for as much as 20 feet—making sinking very difficult. Where the ground is frozen as in the Klondike, no water is encountered in sinking, and no timbering is required. With the exception of shafts sunk in the hope of finding the old creek channel, mining operations on the creek have been confined to the recent stream gravels which overlie the boulder-clay — 'clay bedrock'. These recent gravels with their gold content, really represent mostly a residual product or concentrate from the boulder-clay, moved by the stream. They are in most places less than 10 feet in thickness, but at certain points the boulder-clay extends nearly 20 feet below the stream bed. The gravels are similar to those on Ruby creek, and consist mainly of coarse angular and sub-angular fragments of schist associated with which are pebbles and boulders of quartz and some of granitic rock. Great boulders of the granitic rock 10 feet in diameter were seen in places.

Nearly all the gold that has been taken from Fourth-of-July creek was found between claims Nos. 65 to 77 above Discovery claim, the total amount being probably between $6,000 and $10,000. During the past summer, however, a small patch of fairly rich gravel was found on Twelfth-of-July creek near the mouth of Larose creek, from which several ounces of coarse gold was obtained in a few days, and other small amounts of gold have been found at a few outlying points.

The bulk of the gold in the valley as well as in the tributary depressions was undoubtedly originally concentrated in the old, pre-Glacial channels. The valley of Fourth-of-July creek is so wide, however, and its bedrock floor is so deeply buried under glacial accumulations, that there is very little surface evidence as to the position of the old channel. Near the edge of the Jarvis River valley, the creek flows through a short canyon with schist walls rising nearly vertically to a height of 50 feet in places. This canyon represents a recent stream channel, the old channel being buried under the glacial deposits flanking it.

To prospect for the old channel it would be necessary to sink to bedrock and drift. This would probably prove to be very expensive, and there is no certainty that at any particular point the gravels of the old channel with their gold contents were not swept away by the ice during the glacial period. Whether or not the old channel is found, however, there is still in places sufficient gold in the gravels of the present stream to yield wages or better, but it is very unevenly distributed.

Gladstone Creek. Gladstone is one of the larger creeks of the district and trends in a general way almost due west, entering Kluane lake on its eastern side near the northern end. Its valley, like those of all the other creeks on the eastern side of the lake, is deeply floored with boulder-clay and other glacial deposits. The rocks exposed along the lower 5 or 6 miles of the valley are dominantly the Kluane Schists. Above this, however, the granitic intrusives are almost continuously exposed along the valley walls.

A number of claims are held on this creek, but practically the only gold known to have been recovered was obtained by Messrs. T. T. Murray and A. Swanson who hold Discovery claim and No. 1 below Discovery, Discovery claim being located just below the mouth of Cyr creek and about 2 miles from the mouth of Gladstone. These owners have worked their claims intermittently during the past few years, by the open-cut method, having worked to a depth of possibly 11 or 12 feet. Their mining operations have been entirely confined to the gravels of the present stream, which overlie the boulder-clay, bedrock having been nowhere reached. They have obtained altogether possibly $2,000 or $3,000, the gold being really a concentrate from the boulder-clay, which has been transported by the present stream.

A company of Whitehorse mining men worked this creek during the summer of 1913 with an Empire drill, owned by the Yukon government. They tried to locate the original pre-Glacial channel underneath the glacial deposits, but were apparently unsuccessful.

*Bullion Creek**. "Bullion creek is a typical St. Elias stream. It heads in small glaciers at the summit of the range separating Slims river and Kluane lake from Duke river, and empties into Slims river after a course of about 12 miles. It is a large swift-flowing stream, very variable in its flow, but carrying under ordinary conditions about 2,000 miner's inches of water. Its grade is steep, averaging over 200 feet to the mile, and in flood it assumes a torrential character." The valley of the creek is a deep, steep-walled gorge 2,000 to 3,000 feet or more in depth, which, though narrow throughout, widens somewhat toward its lower end, i.e., as the edge of the Slims River valley is approached. During the Glacial period, Bullion Creek valley was almost completely filled with boulder-clay and associated glacial deposits. After the retreat of the ice, the stream began actively re-excavating its old channel, and from a short distance above No. 20 above Discovery to the lower end of the valley, has not only succeeded in sinking its way through these glacial deposits, but has also cut some distance into the underlying bedrock. Thus from about No. 20 above Discovery to the edge of the Slims River valley, a distance of about 5 miles, the present stream flows through a steep-sided gorge with rock walls rising to heights in most places of from 50 to 200 feet. In the vicinity of Metalline creek which joins Bullion near the upper end of this 5-mile rocky gorge, Bullion creek for about one-fourth of a mile, forces its way through a canyon so narrow that at a short distance it looks like a mere cleft in the rock. This remarkable natural feature is due to a change in the course of the stream at the close of the Glacial period. After the retreat of the ice, the creek was crowded to the north by the wash brought down from Metalline creek and, instead of having only to clear out its old channel as along most other portions of its course, the stream had to sink a new channel in the bedrock; and as the downward cutting was very rapid, the incision is narrow. The former channel is plainly in view where it is cut by Metalline creek, about 200 feet above and on the south side of the bed of the present Bullion creek.

* McConnell, R. G., op. cit., pp. 13A-15A.

Along the greater part of its course from a point a short distance above No. 20 above Discovery, to its head, Bullion creek has not yet reached bedrock, and the creek gravels overlie boulder-clay, the channel walls being also composed of detrital glacial deposits. These glacial accumulations continue to the mouth of the valley, bordering the rock-walled channel of the lower portion of the stream on both sides. They extend also in most places well up the valley walls, reaching to near the elevations of the bordering summits. These deposits, particularly the boulder-clay, have weathered into a great variety of craggy and castellated forms, and constitute a very striking feature of this picturesque valley.

The rocks exposed in the valley of Bullion creek, include both sedimentary and igneous members which range from probably Pre-Cambrian to Tertiary in age. The dominant types are phyllites and limestones, although shales, cherts, greenstones, and rhyolitic intrusives are all somewhat extensively developed. The phyllites are prevailingly greenish, greyish, or yellowish in colour, and cleave readily into thin plates having bright, glistening surfaces from the abundance of mica contained in them. The limestones are nearly everywhere altered to marble, and are mainly white, yellowish, or black in colour. The shales and cherts are mainly dark-grey to black in colour and thinly bedded, although some massive cherts also occur. The phyllites and associated limestones, shales, and cherts, particularly along the lower portion of the valley, closely resemble the members of the Pre-Cambrian Tindir group* and probably belong to that geological formation. They underlie limestone beds in which on Sheep creek, a mile or so to the north, Silurian fossils were found. These beds have all been invaded by greenstones with which they are intimately associated. Certain limestone and shale beds farther up the creek as well as higher up the valley sides, are probably much more recent in age; Mr. McConnell collected fragments of corals from these beds, which are reported to 'indicate a Carboniferous age'**. All these older rocks are cut in places by dykes of a nearly white to yellowish rhyolitic rock which is thought to correspond to a similar intrusive of Tertiary age which occurs in numerous localities in Yukon. The rock section along the valley is highly and brightly coloured, and shows a great variety of shades and tints, adding much to the grandeur and scenic beauty of the valley.

Bullion Creek channel is floored in most places, except in the short canyon in the vicinity of the mouth of Metalline creek, with a layer of loose, recent gravels from 6 to 10 feet in thickness. Near the mouth of the valley, however, the depth to bedrock becomes somewhat greater. These gravels have been worked in places from near the mouth of the valley to about No. 40 above Discovery, but from all the information available, it would appear probable that not more than about $5,000 in gold has been obtained from the entire creek. At the beginning of last season (1914) no claims were held on the creek, but during the summer several locations or re-locations were made, and a few men, generally less than 10, spent a great part of the summer prospecting the gravels of this stream.

On Discovery claim, about 40 ounces of gold were obtained in a few

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* Cairnes, D. D., "Geological section along the Yukon-Alaska Boundary line between Yukon and Porcupine rivers": Bull. Geol. Soc. Amer., vol. 25, 1914, pp. 187-190, and "The Yukon-Alaska International Boundary between Porcupine and Yukon rivers": Geol. Surv., Canada, Memoir No. 67, 1914, pp. 44-58.

** McConnell, R. G., op. cit., p. 6A.

hours in 1903, but in all only about $1,000 is believed to have been mined from this ground. On a number of other claims, including Nos. 14, 30, and 44 below Discovery, small amounts of gold have been obtained. In many places, up to No. 40 above Discovery, an average of $3 to $4 per day per shovel is obtainable, bedrock being reached to about No. 40 above Discovery. In only a few places, however, has gold been found in sufficient quantity to pay wages to miners for more than a few days at a time, the gold being nearly everywhere, apparently, very unevenly distributed.

The Bullion Hydraulic Company, under the direction of Mr. W. L. Breeze, operated along the lower portion of the creek during 1904, 1905, and 1906, and spent, possibly, $300,000, mainly in buildings, equipment, and various initial outlays. Only a small amount of actual placer mining was done, which is believed to have yielded about $1,000 in gold.

It is quite possible that gold in paying quantities may occur in the gravels of the old channel where it occurs along the benches, but these gravels are not known to have been prospected.

The gold on Bullion creek, in common with the other streams in the northwestern portion of Kluane district, is worn much smoother than that from the streams to the east of Kluane lake. It occurs on Bullion creek mainly in flattened pellets, occasionally of considerable size, nuggets up to an ounce in weight having been found. Some fine gold also occurs. The grade of the gold is high, averaging about $18 per ounce.

*Sheep Creek**. Sheep creek resembles Bullion creek in many respects, but is a much smaller stream. It heads with Congdon creek, and after a course of about 8 miles debouches on the flats of Slims river, about a mile below the mouth of Bullion Creek valley- Sheep and Bullion creeks being in general nearly parallel. Sheep creek throughout the lower 3 or 4 miles of its valley, is a very swift stream, the average grade exceeding 300 feet to the mile; but above the mouth of Fisher creek it has a much more gentle gradient.

The valley of the creek, in common with that of the other smaller streams draining the landward slope of the St. Elias range, is deep, steep-walled, and gorge-like in character. During the Glacial period this depression became filled to a depth of 1,000 feet or more with boulder-clay and other glacial accumulations. After the retreat of the ice, the stream immediately commenced re-excavating its channel, and from about the mouth of 74 pup to the lower end of its valley, a distance of between 3 and 4 miles, the creek has cut down into the underlying bedrock. Along this portion of its present course, Sheep creek flows through a narrow canyon with nearly perpendicular rock walls rising to heights in most places of from 100 to 200 feet. Above and below the canyon, the main valley walls rise abruptly 2,000 feet or more to the lofty bordering mountain summits. Throughout this lower portion of its valley, however, the stream in places became superimposed over bedrock to one side or the other of its former channel, and at such points, has been forced to cut downward very rapidly, to maintain grade, and the resulting incisions in such places are very narrow and cleft-like in character. Below Fisher creek, at least, the portions of this old channel which were not again occupied by Sheep creek, and thus still remain undestroyed, lie for the greater part on the left (northeast) side of the present stream. Commencing at about the mouth of 74 pup, and extending upstream,

* McConnell, R. G., op. cit., p. 15A.

the valley of Sheep creek, particularly near the stream itself, is much less rugged and rocky in appearance, as throughout this upper portion of the creek's course, the stream in most places still overlies the boulder-clay, not having as yet been able to sink its bed through the accumulations of this material. This boulder-clay, with the other glacial debris, borders the creek channel and extends well up on the valley sides. The stream here has a moderately gentle grade, and flows in a somewhat open valley which is strikingly in contrast with the rock canyon below, through which the water rushes and leaps over a succession of falls to the point where it joins the valley of Slims river.

The rocks exposed along Sheep creek are extremely varied in age and character. Along the lower portion of its course, limestones and greenstones predominate, and near the edge of Slims River valley, some cherts also occur intimately associated with certain of the limestone beds. The oldest rocks exposed include a group of marbles, cherts, and shales. The marbles are irregularly streaked or striped in appearance—nearly white and black streaks alternating. The cherts are prevailingly dark in colour, although white or greyish members occur, and nearly all are stained reddish with iron oxide. These older beds are overlain by more massive limestones which contain Silurian fossils. On the mountains to the north, Carboniferous limestones, shales, argillites, and associated beds also occur. All these beds are in places considerably distorted, folded, and broken, and brecciated zones are locally prominent. They have been invaded by greenstones which are extremely varied in character, and include diorites, diabases, andesites, and basalts. Along the upper portion of Sheep creek, Tertiary lignite-bearing beds are somewhat extensively developed. These include mainly conglomerates, sandstones, shales, clays, and associated tuff beds.

Mining on Sheep creek has been practically all confined to the comparatively shallow gravels of the present stream channel between claims Nos. 52 to 75 above Discovery. In all about $10,000 in gold is thought to have been obtained from the stream. The richest ground found was on No. 74 and the lower part of No. 75, from which Fisher brothers obtained $7,000 in about 40 days. The richness of this ground is apparently due to the fact that it lies just below a pup coming in from the left, which a short distance above its mouth apparently crosses the old stream channel.

The distribution of the gold in the gravels of the present stream is very irregular and, in most places, the amount of gold is small. Undoubtedly other points remain, however, like Nos. 74 and 75 above Discovery, that occur below the mouths of tributaries cutting the old channel on the benches, which will pay to work. It would also seem highly advisable to prospect the old channel which, where still intact from a short distance above No. 74 pup to the mouth of the valley, lies on the benches, but from a short distance above 74 pup, is below the level of the present stream. The bulk of the gold was originally deposited in this old channel, and there it still remains except where swept away by the ice during the Glacial period.

Burwash and Tetamagouche Creeks.* Burwash creek heads in the glaciers of the St. Elias range, and empties into Kluane river 5 or 6 miles below Kluane lake. It has a length, measured along its valley, of 18 or 20 miles and trends for a great part of its course across a high plain or platform-like surface that fronts the St. Elias range in this vicinity. Burwash creek is also

* McConnell, R. G., op. cit., pp. 15A-16A.

a typical, swift, mountain stream, comparable in size with Bullion creek, but with a grade less than that of Bullion, amounting to about 125 feet per mile along the main, central portion of its course. Like all glacier streams, its daily and seasonal flow is extremely variable, depending on the strength of the sun; and in times of flood, it becomes a raging torrent.

From near its head to the point where it enters the valley of Kluane river the stream is bordered on the left by a mountain wall which rises abruptly in most places for over 2,000 feet from the creek bed. On the opposite or right-hand side (looking downstream), however, the creek is flanked throughout a great part of its course by the high plain, before mentioned, the surface of which is composed of glacial deposits. Into this glacial upland tract, and prevailingly along its extreme edge, Burwash creek has cut a deep, trough-like valley. Along most parts of its course, the stream channel is bordered on the left by a rocky mountain wall, and on the right by more gentle slopes underlain by detrital materials and covered with grass and underbrush. At a few points the stream flows through narrow rock-walled canyons which are difficult to penetrate except in low water. The canyons are the result of the stream at these points having become superimposed over rock spurs projecting from the mountain sides. Above the upper canyon, the valley of Burwash creek suddenly opens out, and has gently sloping grassy slopes reaching up from 30 to 80 feet to the upland surface of the glacial platform fronting the St. Elias mountains.

Downstream from apparently just above the upper canyon, Burwash creek, in the process of deepening its channel, slowly and intermittently shifted its course to the left until it reached its present position, with the result that there now occur in most places along the right side of the valley, a succession of rock-cut channels containing stream gravels, which represent former positions of the creek. These channels necessarily become gradually lower in elevation as the present creek bed is approached, but are now in most places covered with glacial and other superficial detrital materials. They have nevertheless been explored at certain points, where they have been found at no great elevation above the present stream.

Tetamagouche creek is the largest and most important tributary of Burwash creek, and joins that stream on its left bank either on or just above claim No. 60 above Discovery. The creek follows a rather straight southeasterly course through a break in the mountains which flank the left side of Burwash creek, and in the upper portions of its course occupies a somewhat open valley with gentle slopes clad with grass and underbrush. Nearer Burwash creek, however, it forces its way through a rock-walled canyon, so narrow as to be cleft-like in appearance.

The rocks exposed along Burwash and Tetamagouche creeks are somewhat varied in character, but dominantly belong to an igneous, basic to semi-basic group including mainly diorites, diabases, andesites, basalts, and dunite—greenish and reddish amygdaloids being locally very prominent. In places, also, sedimentary rocks occur including for the greater part, shales, slates, argillites, cherts, limestones, and cherty conglomerate, in which Carboniferous and Triassic fossils were found; these beds have been intensely invaded by the igneous members. At a few points also, these older rocks are cut by granitic intrusives probably of Jurassic or Cretaceous age. All are pierced in places by dykes of a nearly white, greyish or yellowish rhyolitic rock which is thought to be of Tertiary age.

The creek gravels of Burwash and Tetamagouche creeks are in most places shallow, and are generally somewhat coarse. Along Burwash creek they are coarser, in most places, near the surface and also as the right bank of the valley is approached, most of the large boulders having rolled down from the hill side on the right bank of the stream. The bench gravels remain frozen throughout the year; but the creek gravels are only frozen in winter, and even then are in few places if anywhere frozen down to bedrock, remaining unfrozen at most points below a depth of 10 or 11 feet. This condition makes prospecting in the creek very difficult, owing to the difficulty of handling the water coming into the bottoms of the shafts.

From a mining standpoint, Burwash has been much the most important of the Kluane creeks, as more gold is believed to have come from the gravels of this stream than from all the other creeks of the district combined. Coarse gold has been found from the foot of the lower canyon upstream for a distance of 8 miles or more, but it is impossible to ascertain the exact amount of gold that has been mined. From all the information available it seems probable that in all between $30,000 and $40,000 in gold has been obtained; and an additional amount of approximately $2,000 has come from Tetamagouche creek. The gold is characteristically very flat and well worn, that obtained from the benches being mostly coarse, and that from the creek much finer, and in places quite fine. Nuggets worth as much as $25 or $30 have frequently been found, but the largest known to have come from Burwash creek was found on claim No. 65 above Discovery. This nugget weighed 5 ounces, including less than one ounce of quartz and rock. The gold from this creek is all very pure, assaying generally from $18 to $18.10 per ounce.

About 40 claims were held on Burwash creek in the spring of 1914, and when visited by the writer, early in August, 14 men were working along the stream. The creek has been more or less prospected and mined from the lower end of the lower canyon up to No. 66 above Discovery. Above No. 66, one shaft was sunk to a depth of 21 feet, but with this exception practically no work has been done in the creek gravels, and there has been very little prospecting of the benches. The gravels of Burwash creek along the present stream have at a number of points yielded very satisfactory returns, and the channels along the right bank of the creek have been proved to contain gold in important amounts at several points.

The creek gravels, particularly above the mouth of Tetamagouche creek, certainly warrant further exploitation, and the old channels on the right bench deserve careful investigation. It would seem highly probable that there is still much gold along this creek, that can be mined at a profit. Mining operations to be successful, however, must be prosecuted carefully and under skilled and experienced management.

The gold that has been obtained from Tetamagouche creek has practically all been found below the canyon, and appears to be everywhere very 'spotted' or unevenly distributed throughout the gravel. There are a number of points below the canyon where sluicing will still yield about $3 per day per shovel, an amount, however, that is considerably below the wage rate of the district.

Arch Creek. Arch creek lies to the northwest of Burwash creek, and joins Donjek river from the right about 28 miles above the mouth of the Kluane river. It is a typical, swift, mountain stream comparable in length and volume of water with Sheep creek, and in many ways much resembling that stream.

The valley of Arch creek is a deep, steep-sided trough-like depression, the walls of which rise abruptly to the mountain summits on either side, which rise to elevations of over 2,000 feet above the mouth of the stream. In this depression as in others already described, vast deposits of boulder-clay and other glacial deposits accumulated, and the consequent re-excavation followed. At two points, at least, the new channel became superimposed over rock spurs to one side of its former course, with the result that the stream, cutting downward very rapidly through these rock points, produced the narrow and cleft-like incisions, now known as the upper and lower canyons.

The lower canyon commences about $1\frac{1}{2}$ miles above the mouth of the creek and extends upstream for about one mile. Above it the valley widens and, until the rock-walled upper canyon is reached, has more gentle slopes. Above the upper canyon, the valley again opens out, and the slopes are more gently inclined. The lower portions of the valley sides, except in the canyons, are in most places, deeply covered with glacial and other detrital accumulations.

The rocks exposed along the lower portion of Arch Creek valley are prevailingly sedimentary in character, and include mainly limestones, shales, cherts, and argillites. These are believed to be, for the greater part at least, of Carboniferous age; but some of the members may be older. The more massive limestones which appear to be the oldest beds exposed, resemble the Silurian beds on Sheep creek, and may be of that age. On the mountains to the south, Triassic beds were also identified. The sedimentary members along the creek have been invaded by an extensive group of igneous rocks including mainly diorites, diabases, andesites, and basalts, which are most strongly developed along the upper portion of the valley. All these older rocks are in places pierced by granitic intrusives which are thought to be of Jurassic or Cretaceous age.

Arch creek has been worked more or less since 1904, but although promising prospects have been found at several points in the lower canyon, only a small amount of gold has been obtained. Practically all the gold that has been found, so far as is known, was obtained from the lower canyon, within which the gravels are shallow and easily worked. Neither above or below this canyon, however, has bedrock been reached. During 1914 about 6 claims were held on this creek, all of which were located along the lower portion of the stream. When visited in August, Mr. R. W. and Mr. W. B. Lamb were engaged in sluicing immediately below the lower canyon in an attempt to reach bedrock, but although they had been so engaged most of the season, they had as yet not succeeded in penetrating to the bottom of the valley deposits. The main difficulty with which they had to contend, appeared to be the presence of numerous very large boulders, some of which were 6 to 8 feet or even more in diameter. These boulders, although associated with the recent gravels, are really a residue from the glacial deposits which have already been transported by the stream.

There is still undoubtedly some gold in both the upper and lower canyons, and in places it may possibly be in sufficient quantities to pay for mining. It would appear, however, that if placer gold in important amounts is found elsewhere than in these canyons, it will be mainly on or near bedrock in the old channel of the stream or, even probably, in portions of the present stream's channel where it has become superimposed over its former course. No gravels occurring in this position have so far been explored.

Undoubtedly the two canyons represent very recent channels, and the position of the former course of the stream lies to one side of them. An old channel plainly lies to the left of the lower canyon, and the indications would apparently warrant the expense of prospecting and exploiting this channel and its continuation upstream. However, as in the case of all these intensely glaciated valleys, it is quite possible that the ice during the Glacial period may have swept away the gravels and whatever gold they contained. That gold occurred in the former channels of a number of the creeks of Kluane district is indicated by the fact that some gold, in places in important amounts, is found in the recent gravels, which represent a much shorter period of concentration than the gravels of the pre-Glacial channels.

Nansen District

General Description. Nansen creek is one of the headwater tributaries of Nisling river, and joins this stream from the north on its right bank. It flows in a general way almost due south and lies to the north of Aishihik lake and west of Carmack on Lewes river, the mouth of Nansen creek being about 30 miles from Carmack and about 29 miles from Aishihik village at the northern end of Aishihik lake, measured as the crow flies. The term Nansen district as used in this report includes only the area in the vicinity of Nansen creek, which was mapped by the writer during the past summer (1914). This district is about 10 miles long measured in a north and south direction, by $7\frac{1}{2}$ miles wide. It includes all of Nansen and Victoria creeks with most of their tributaries, and embraces all the streams in that locality which have been found to contain placer gold.

Nansen creek to the mouth of Summit creek, has a length of about 9 miles, and Summit creek, which is really its continuation, has an additional length of about $1\frac{1}{2}$ miles. It is a gently flowing stream with an even grade, and the volume of water varies considerably with the seasons, but is at no time very great. When visited in July, although higher up along the stream's course there was considerably more water, along the lower portions of the valley there was not sufficient to maintain the stream, and the only water in the channel consisted of occasional disconnected pools. The season, however, had been exceptionally dry. The relatively small amount of water near the mouth of the stream was largely due to the water sinking through the loose sands and gravels which overlie the boulder-clay along this portion of the valley bottom. A mile or so higher up, there was 100 to 200 miner's inches or even more, and on the East Fork and on Summit creek, the two uppermost tributaries of Nansen creek, there was approximately 50 miner's inches of water. Several of the tributaries appeared to carry almost as much water as the parent stream below their confluence, showing that at different points along the creek there is loss of water from underground seepage.

Victoria creek is approximately of the same length as Nansen creek, being about 10 miles long, but it contains more water, possibly twice as much.

The valleys of Nansen and Victoria creeks are wide, flat-bottomed, typically U-shaped depressions with steeply inclined walls which rise to an upland surface having a general elevation of about 5,300 feet, the mouth of Nansen creek being about 3,700 feet above sea-level. Occasional summits rise a few hundred feet above the general upland, but throughout the district the hills are generally well rounded and have gentle slopes.

During the Glacial period, all the larger valleys of the district became partly filled with boulder-clay and other glacial deposits which floor these depressions to near the heads of the streams. As the district, however, is situated near the edge of the glaciated zone in Yukon, the ice action did not extend more than a few hundred feet up the valley sides, and consequently the glacial deposits do not reach far above the present main valley bottoms. The tributary streams in most places, have deep, narrow, steep-walled valleys, the larger of which are in most places floored with at least a few feet of boulder-clay overlain by other superficial detrital accumulations.

The district as a whole is very sparsely forested, but spruce trees sufficiently large for building cabins and for ordinary placer mining operations, grow in places in the valley bottoms, in some of the draws, and on occasional sheltered portions of the hillsides. A dense growth of underbrush from 4 to 6 feet in height, and consisting mainly of dwarf birch and willows, extends over nearly the whole district, including even portions of the upland surface.

The rocks exposed in Nansen district are dominantly igneous and metamorphic, and range from probably Pre-Cambrian to Tertiary in age. The southern end of the district northward to include portions of Webber and Dome creeks, is composed almost entirely of old schistose rocks—mainly mica schists, quartz-mica schists, and quartzite schists. These rocks belong to the Yukon group*, the members of which are extensively developed in Yukon and Alaska, and are almost undoubtedly of Pre-Cambrian age.

The geological formations exposed throughout the remaining more northerly portion of Nansen district, are practically all of igneous origin, and include three rock groups—an older basic to semi-basic group, and two more recent, acid groups which are genetically very closely related. The members of the more basic group are much the most extensively developed, and extend over the greater portion of the northern end of the district. They are apparently of Carboniferous or early Mesozoic age, and are all characteristically dark green in colour. They range in character from dense aphanitic rocks in which none of the mineral constituents are discernible to the unaided eye, to medium textured, holocrystalline members in which hornblende, biotite, feldspars, or other minerals are quite apparent, and include a number of types, mainly diorites, diabases, andesites, and basalts.

The more acid rocks are of two groups, a deep-seated or plutonic group of intrusive rocks that have prevailingly a granitic habit, and a related volcanic group including mainly granite porphyries and rhyolites. The granitic intrusives are greyish to pinkish in colour, and have the general appearance of granites. They cut the members of the more basic group, and are thought to be of Jurassic or Cretaceous age. The volcanic rocks appear to constitute, at least mainly, marginal or surface phases of the deep-seated granitic intrusives, but may in some cases represent later eruptions from the same parent magma. These acidic volcanics range in character from dense, cherty rhyolites to medium-textured granite-porphyries. The rhyolitic members of this group along the East fork of Nansen creek, and elsewhere are much silicified, and resemble cherts. They are, in fact, locally termed by the miners, 'quartzites', but in places exhibit quite distinct

*Cairnes, D. D., "Geological section along the Yukon-Alaska Boundary between Yukon and Porcupine rivers": Bull. Geol. Soc. Amer., vol. 25, 1914, pp. 184-187, and "The Yukon-Alaska International Boundary between Porcupine and Yukon rivers": Geol. Surv., Canada, Memoir No. 67, 1914, pp. 38-44.

quartz and feldspar phenocrysts. These rocks pass gradually into the more coarsely textured granite porphyries, which are generally light grey in colour, but like the rhyolites are in many places stained yellowish to reddish with iron-oxide.

Discovery of Gold. Placer gold is believed to have been first found in Nansen district by Mr. Henry S. Back in July, 1899. Mr. Back had come from Selkirk on a prospecting trip with a partner, Mr. Ham. Kline, and found what he considered to be good panning on Nansen creek near the mouth of Discovery creek. After remaining in this vicinity two or three days, the partners continued on their journey, and no one is known to have further investigated the discovery, or to have found gold in the vicinity, until the spring of 1907, when Mr. Back returned with his son Frank H. Back and has since been identified with the district.

The first claim to be actually recorded was Discovery claim on Nansen creek, which was staked on June 13, 1910, by Frank H. Back and Tom Bee. Since that time mining and prospecting has been intermittently carried on in this locality. Practically all the creeks in Nansen district were at one time staked from end to end, but many of the claims were allowed to lapse.

Gold-bearing Gravels. Practically all the placer gold that has been obtained from Nansen district has come from Nansen creek and from two of its tributaries—Discovery creek and the East fork of Nansen creek with its tributary the South fork of the East fork of Nansen creek, these two forks or creeks being locally designated for convenience, the East and South forks, respectively. Prospects have been found on other tributaries of Nansen creek, as well as on Victoria creek, and on one or more of its tributaries, but no gold is known to have been mined from these streams.

Along Nansen creek, the valley bottom is floored with a thick deposit of boulder-clay, overlying which is a covering, in places 20 to 25 feet thick, of sands, gravels, muck, and associated deposits. The gold that has been obtained, has been distributed through the gravels, in places being near the surface, and at other points being on or near the boulder-clay—the 'clay bedrock'.

From Discovery claim which is just above the mouth of Discovery creek, about $1,200 to $1,500 has been mined, and on No. 7A above Discovery, Messrs. Printz and Delapola obtained 45 ounces of gold by ground sluicing from the surface gravels between August 5 and October 10, 1912. Other smaller amounts of gold have also been found, the total amount of gold obtained from Nansen creek being probably between $2,000 and $3,000.

From about claim No. 7 below Discovery up to Discovery claim, fine gold is known to occur in the gravel overlying the boulder-clay, but the prospecting so far performed seems to show that it is not in sufficient quantities to pay for mining. This condition is due partly to the width of the valley, and to the consequent spread of the gold-bearing gravels over a broad area in places 200 feet or more wide. Gold is known to occur in important amounts also between the mouths of Courtland creek and East fork, where it has been found mainly at the surface, occurring mostly in certain small mounds or irregular wave-like piles of gravel.

During the winter of 1913-14, Messrs. Betterton and Morgan brought in a Keystone drill, and sunk 10 holes on or near Discovery claim on Nansen creek. The holes are reported to have all penetrated the boulder-clay, but it is not known whether or not any of them reached actual bedrock.

On Discovery creek several claims have been worked or prospected, in some cases with encouraging results. Gold valued at $200 or $300 was obtained at the mouth of Eliza creek during the winter of 1912-13 by Messrs. Neilson, McDad and McLean. Also in the spring of 1912, Mr. George McDad, at a point about 1½ miles from the mouth of Discovery creek, sunk to bedrock, a distance of 18 or 20 feet, and crosscut from the bottom of the shaft. He obtained an encouraging amount of gold, the exact value of which is not known to the writer, but it is reported to have been about $300.

The largest nugget discovered in Nansen district was found by Messrs. Neilson and McLean on Discovery creek and weighed just about one ounce.

It would seem quite possible that the bedrock channel in Discovery creek may contain gravels carrying important amounts of gold, but this channel has not been reached so far, unless in Mr. McDad's shaft and crosscut above mentioned. At the mouth of the creek the stream, since the retreat of the glacial ice, has become superimposed over a rock spur along the right or north side of its valley, and has there cut a narrow canyon through the greenstones, sufficiently deep to be on grade with the present surface of the valley bottom of Nansen creek. The former channel of Discovery creek plainly lies to the left (south) of this canyon and only a few feet distant from it. It would seem advisable to at least explore this easily accessible portion of the old channel.

The East fork of Nansen creek, to the mouth of the South fork, is covered by seven claims and a fraction. The lower four claims and fraction are owned by Messrs. Conrad Printz and E. L. C. Delapola, and the upper three claims, Nos. 5, 6, and 7, are the property of Mr. Albert Cristensen. All this ground along the East fork is thought to contain gold in paying quantities, and it is the intention of the owners to mine as soon as possible all that has not already been worked.

From the mouth of the East fork up to near the upper end of claim No. 4, the present stream gravels, which are the gravels there being worked, overlie boulder-clay, the depth to this 'clay bedrock' being about 6 feet. This ground has been worked by the owners by open-cutting and sluicing during portions of the past two summers. Mr. Printz claims that the gravels along this portion of the creek carry gold to the amount of about $1.50 per cubic yard.

Commencing at about the foot of Mr. Cristensen's ground, the boulder-clay has been entirely removed from the channel of the present stream, and the gold-bearing gravels are on bedrock which is, along this portion of the creek, dominantly a highly silicified and chert-like rhyolite. Mr. Cristensen has been working his holdings intermittently for the past three years, open-cutting and sluicing in summer, and drifting in winter.

Along the portions of claims Nos. 5, 6, and 7, that have been worked, the depth to bedrock is from 10 to 20 feet, there being 4 to 6 feet of surface muck overlying the gravels. The gold is mainly on bedrock, and extends into cracks and crevices of the rock for 3 feet or more. The pay gravels where being worked when visited by the writer, were about 15 feet wide and carried about 40 cents in gold to the square foot of bedrock. Higher up, where the pay streak is only 12 feet wide, the gravels are claimed to carry 80 cents to the square foot.

In all, until July 1914, possibly about $2,000 had been obtained from the East fork, and the largest nugget found was worth $5.80.

Near the mouth of the South fork, Messrs. Miller and Shaw have been working during portions of the past three winters, and during part of last summer (1914). Their mining has all been done by the method of drifting on bedrock, hoisting from a shaft, and sluicing. The width of the pay gravels worked, ranges from 10 to 20 feet, and the depth to bedrock is about 20 feet. The bedrock there is a rhyolite similar to that lower down on the East fork where Mr. Cristensen is working, but in places is somewhat less silicified and cherty. During the winter of 1913-14 the owners obtained about $1,200 in gold from their operations, this being the clean-up from 4,500 8-pan buckets; in other winters they were much less successful. Some of the nuggets obtained are composed largely of a lustrous black telluride mineral, which occurs associated with the gold.

On Webber creek, three shafts have been sunk, 30, 22, and 40 feet, respectively, to bedrock, and gold in encouraging amounts is reported to have been found. When visited in July (1914) Mr. Courtney Mack was engaged in extensive ground-sluicing operations, in an attempt to strip bedrock by this method, and to cheaply and quickly handle the overlying, supposedly gold-bearing gravels. A section exposed there showed from 3 to 6 feet of muck overlying the boulder-clay which extends down to bedrock.

On Back creek, a tributary of Victoria creek, Mr. John Rymar sank three shafts on claim No. 4 below Discovery, which are reported to have reached bedrock at depths respectively of 26, 26, and 30 feet. Gold in encouraging amounts is reported to have been found in these shafts and as a result, the creek has been for the greater part re-located -the claims having previously lapsed.

It is thought that in all, only from $5,000 to $7,000 in gold has been obtained from Nansen district; but systematic prospecting has been carried on at only a few points and it would seem possible that other valuable placer deposits may yet be found. Special attention should be devoted to the exploitation of the bedrock channels of the tributary streams, as although the amount of concentration may have been less in the small than in the larger valleys, the channels containing the gold-bearing gravels can be much more easily found along the tributary streams, than in the larger valleys; and, on the upper portions of the smaller valleys there was little or no ice during the Glacial period, and whatever gold was accumulated there in all probability still remains practically where it was originally concentrated.

*Upper White River District**

Upper White River district adjoins the 141st meridian which forms the Yukon-Alaska Boundary line along the upper portions of White river included within Canadian territory. From time to time for a number of years past, it has been reported that placer gold has been found within this area; the first authentic discovery that is known, however, was made on Pan creek during the winter of 1912-13 by Messrs. William E. James, Peter Nelson, and Frederick Best, who claimed to have found good gold prospects there, but stated that they were forced to stop work on account of the inflow of water when bedrock was reached. In the spring, Messrs. James and Nelson went farther west and became the original locators in Chisana district, Alaska.

During the autumn and winter (1913-14) following the Chisana discovery, prospectors rushed into Upper White River district, which is within

* Cairnes, D. D., "Upper White River District": Geol. Surv., Canada, Memoir No. 50, 1915.

about 30 miles of the original discovery at Chisana, and a great many placer claims were located, several streams, including Pan, Bowen (Dominion), Hidden, Cash (Gold), and Indian creeks being staked practically from end to end. The only creeks, however, on which gold sufficient to constitute promising prospects has been found, are Pan, Bowen, and a tributary of Bowen known as Hidden creek.

Pan creek is about $3\frac{1}{2}$ miles long and drains over the southwestern side of Nutzotin mountains into Tchawsahmon creek. The valley of the creek is a deep, gorge-like, rock-walled incision, through which the stream, particularly along the lower portion of its course, rushes with great force, tumbling over a number of falls to reach Tchawsahmon valley.

The rocks exposed along Pan creek comprise both sedimentary and igneous members. The sedimentary rocks include mainly shales, argillites, cherts, greywackes, conglomerates, and limestones of Carboniferous or early Mesozoic age. These are extensively invaded by basic to semi-basic rocks including diorites, diabases, andesites, and basalts, which are thought to be, mainly at least, of about Cretaceous age.

The gravels along Pan creek are in most places narrow, and down to the edge of Tchawsahmon valley, are thought to be from 5 to 40 feet deep, except at or near the lips of the various falls along the stream, where bedrock in some cases is exposed. The gravels are very coarse, boulders several feet in diameter being very plentiful, and as they thaw in summer, and in winter are never frozen near bedrock, prospecting by sinking is almost impossible; consequently, the gravels on bedrock have nowhere been tested so far as is known. Some coarse gold has, however, been found in places along the rock rims of the creek channel, and in the gravels near the surface, so that further investigation is warranted. The best way to thoroughly test this creek would be to ground-sluice the gravels, fluming the surplus water when bedrock was being cleaned. In this way, with the volume of water in the creek at most seasons, it is quite feasible to strip the bedrock and exploit the overlying gravels, though the large boulders would be troublesome.

Three holes have been sunk in Tchawsahmon valley opposite the mouth of Pan Creek valley, the deepest of which is down about 90 feet. The ground encountered there was frozen to the bottom of the 90-foot shaft, where water was encountered and sinking was abandoned. None of the holes reached bedrock.

Prospecting in Tchawsahmon valley is not considered advisable at present for a number of reasons. The wide valley bottom—about one mile in width opposite the mouth of Pan creek—is floored with glacial and other superficial detrital accumulations to a depth of 100 feet or more, and there is no indication at the surface as to the position of any underlying bedrock channel, so that prospecting under such conditions would be very expensive and have little chance of reward. Besides there is no chance of finding the continuation of the bedrock channel of Pan creek within Tchawsahmon valley, nor of any of the streams tributary to this depression, as glacial ice has planed away the mouths of these tributaries and scattered the gravels with whatever gold they may have contained. Any gravels which were deposited on bedrock in Tchawsahmon valley, and which might have been gold-bearing, have also in all probability been also redistributed by the glacial ice.

Bowen creek like Pan creek drains down over the southwestern face of the Nutzotin mountains, and empties into Tchawsahmon creek. This stream, as well as its tributary, Hidden creek, is in most respects much like Pan creek. Some coarse gold has also been found in them, but so far not in sufficient quantity to pay for working. However, very little systematic prospecting has been done in this locality.

Copper Deposits

The only copper deposits that are known to occur in southwestern Yukon which have actually been mined or which under present conditions can be worked at a profit, are those in the Whitehorse Copper belt, near the town of Whitehorse. This area lies within the limits of the map accompanying this report, but was not examined by the writer during the past summer, as Mr. McConnell spent the summer of 1907 there and has written a very complete and exhaustive report[1] on the deposits.

Deposits carrying copper minerals have been found at a number of other points in the portion of southwestern Yukon dealt with in this report, mainly in Upper White River district, Kluane district, and in the vicinity of Aishihik lake. None of these deposits have yet been actually shown to be of economic importance, but some of them may be of value.

The copper deposits of Upper White River district, although possibly of future importance, cannot be exploited, until better transportation facilities are provided. These deposits have been described in detail in a memoir[2] recently written by the writer.

The copper deposits generally spoken of as the Aishihik lake, deposits which really occur on Gilltana lake[3], a small body of water near by, and an isolated occurrence along Hutshi river,[4] a tributary of Nordenskiöld river, also promise to have future value, but under present conditions cannot be profitably mined.

The only other deposits of copper minerals known to be of economic importance, in this portion of southwestern Yukon, occur in the extreme northwest corner of Kluane district, in the vicinity of Quill, Burwash, and Tetamagouche creeks.

The area or belt through which these copper deposits are distributed, lies along the east side or left bank of Tetamagouche creek, and extends northward from Burwash creek to include the upper portion of Quill creek. Throughout this belt a great number of mineral claims have been located from time to time, commencing about the year 1908, but most of these have now lapsed.

The rocks are dominantly of igneous origin, although some sedimentary beds occur. The igneous members include mainly diorites, diabases, andesites, and basalts, certain reddish and greenish amygdaloids being particularly conspicuous. All these igneous rocks for convenience in description will in this report be referred to by the general term 'greenstones'. They are apparently of early Mesozoic or possibly of Carboniferous age, and very

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[1] McConnell, R. G., "The Whitehorse Copper belt, Yukon Territory": Geol. Surv., Canada, 1909.

[2] Cairnes, D. D., "Upper White River District": Geol. Surv., Canada, Memoir No. 50, 1915, pp. 133-141.

[3] Cairnes, D. D., "The Gilltana Lake claims": Geol. Surv., Canada, Sum. Rept. for 1908, pp. 30-31.

[4] Cairnes, D. D., "Mack's Copper": Geol. Surv., Canada, Sum. Rept. for 1908, pp. 29-30.

closely resemble the members of the 'Older Volcanics'* in Upper White River district, with which the copper deposits are there associated. The sedimentary rocks include mainly shales, cherts, argillites, and limestones of Carboniferous or Mesozoic age, extensively invaded by the greenstones, the sediments occurring in most places as mere patches overlying the igneous members.

Throughout this belt, copper minerals, mainly malachite (green copper stain) and also some azurite (a blue copper stain) and bornite are somewhat widely distributed, and occur associated with calcite, quartz, and epidote, in the greenstones—mainly in the reddish amygdaloids. These minerals either follow breaks or fault planes, or ramify through the rocks along irregular fissures, joints, or cracks. The copper and associated minerals replace the greenstones in which they occur, and in places the containing rocks are bleached to a nearly white or pale yellowish colour for 6 to 12 inches on either side of the mineralized fissures, joints, etc.

In places the rocks are only slightly stained along cracks, fissures, etc., in other places, calcite or quartz occurs associated with malachite, azurite, and bornite. The deposits are very irregular in form and distribution, and are usually not very persistent. The only sulphide noted in the belt is bornite, and the thickest deposit that is known to have been found carrying this mineral in any perceptible amount, has a thickness of about 4 feet. This deposit is situated near the summit of one of the highest mountains immediately north of Burwash creek, at an elevation of approximately 6,500 feet above sea-level or about 2,500 feet above the mouth of Tetamagouche creek. The deposit occurs in a reddish amygdaloid which is much altered, in places, to epidote and through it in places, streaks of almost pure bornite occur, from 1 inch to 3 inches in thickness. The remaining portions consist largely of more or less replaced wall-rock with which is associated some calcite, quartz, epidote, malachite, and disseminated bornite.

Possibly the most important occurrence discovered in this belt, is that locally known as 'Jacquot's'. This deposit is situated at a point about 2,400 feet in elevation above the mouth of Tetamagouche creek, and occurs in a dark, dense, reddish basaltic rock which is in places amygdaloidal. The ore-material which follows a well-defined fault zone with a nearly flat dip, is from 12 to 24 inches in thickness, and consists mainly of bornite, malachite, epidote, calcite, quartz, and more or less replaced wall-rock. An average sample, taken across the deposit at a point where it has a thickness of 18 inches, was assayed by the Mines Branch of the Department of Mines, Ottawa, and proved to contain: copper, 33·12 per cent, gold, none, silver, none. Stringers containing bornite are also exposed in the lower canyon of Burwash creek but are all less than 20 inches in thickness.

Although copper stain, associated in places with bornite, is so widely distributed, no deposit thicker than Jacquot's was seen, that contains nearly so high a percentage of copper. Very few of the deposits of any kind are more than 2 feet in thickness, and all that were seen are low grade and give little promise of containing much ore.

One locally well known occurrence, somewhat different from the ordinary type represented, is located about 1½ miles up one of the extreme headwater tributaries of Quill creek. This deposit consists of a reddish basaltic

* Cairnes, D. D., "Upper White River District": Geol. Surv., Canada, Memoir No. 50, 1915, pp. 87-93.

rock, amygdaloidal in places, throughout which for a width of 70 feet or more, green copper stain is somewhat evenly and plentifully distributed. An average sample was taken across the best 70 feet of this deposit, which was assayed by the Mines Branch of the Department of Mines, Ottawa, and proved to contain: copper 1·43 per cent, gold, none, silver, none.

None of the copper deposits that have so far been discovered in this locality could be profitably worked at present even under much more favourable conditions than now exist, as none of them are sufficiently extensive or persistent to afford any considerable tonnage of merchantable ore. However, as copper is so generally disseminated throughout the belt, it is quite possible that somewhere workable deposits will yet be discovered; therefore further prospecting is recommended.

Coal

Measures containing valuable seams of coal, have for a number of years been known to be somewhat extensively developed in southeastern Yukon, mainly in three localities—Tantalus[1], Braeburn-Kynocks[2], and Whitehorse[3] coal areas, all of which have already been described somewhat in detail by the writer. Tantalus coal area extends along Lewes and Nordenskiöld rivers; Braeburn-Kynocks coal area crosses Klusha creek and Hutshi river, tributaries of the Nordenskiöld; and Whitehorse coal area lies a few miles to the southwest of the town of Whitehorse.

Two small areas of lignite-bearing beds, occurring respectively on Sheep creek and on Kimberley and Telluride creeks in Kluane Mining district, have been briefly described by Mr. McConnell[4]. In addition, a coal field, which contains a number of valuable seams of lignite of good quality, and is here designated the 'Duke River Coal area', has recently been discovered in the northwest corner of Kluane district.

The lignite-bearing beds, which occur along the upper portion of Sheep creek, include mainly greyish sandstones, and conglomerates, grey to black shales, also occasional beds of tuff. These beds include several seams of lignite of good quality, one of which is at least 6 feet in thickness. An average sample taken across a seam, 3 feet thick, exposed in the lower or southeastern end of this Sheep Creek area, was analysed by the Mines Branch of the Department of Mines, Ottawa, and proved to contain:

	Per cent
Moisture	10·9
Ash	9·6
Volatile matter	41·0
Fixed carbon (by difference)	38·5

The rocks of the Duke River Coal area resemble those along Sheep creek, except that at the points where sections are best exposed and were examined, no tuff beds were noticed with the sediments. The beds of this

[1] Cairnes, D. D., "Preliminary Memoir on the Lewes and Nordenskiöld Rivers Coal District": Geol. Surv., Canada, Memoir No. 5, 1910, pp. 30-38, 48-55; *also see* Map 10A.

[2] Cairnes, D. D., Geol. Surv., Canada, Memoir No. 5, 1910, pp. 30-38, 49-50, *also see* Map 11A.

[3] Cairnes, D. D., "Report on a portion of Conrad and Whitehorse Mining Districts, Yukon": Geol. Surv., Canada, 1908, pp. 20-21.

[4] McConnell, R. G., "The Kluane Mining District": Geol. Surv., Canada, Sum. Rept. for 1904, pp. 7A, 18A.

area include mainly loosely or only partly consolidated black and greyish shales and clays, and yellowish to greyish sands and conglomerates, which include occasional intercalated seams of lignite. Fossil plants were collected from the beds of this area, and from those along Sheep creek; these after a preliminary examination have been forwarded to a specialist for more definite determination. They are, however, known to be of Tertiary age and they appear to indicate that the beds from which they were obtained, belong to the Kenai series* which includes the oldest known Tertiary sediments in Yukon and Alaska, and is generally referred to the upper Eocene.

The beds of the Duke River area are developed throughout a belt having a width of from 1 mile to 5 miles, which extends at least from Duke river to the Donjek, a distance of about 15 miles. Good sections of these rocks are exposed along the head of the left fork of Burwash creek, and along the left bank of a tributary of Duke river. At one point along this tributary of Duke river, a small sub-tributary has cut a huge amphitheatre about 1,000 feet deep into these beds, and along the walls of this great natural excavation, and extending up the sidehills above it, a section from 1,200 to 1,500 feet in thickness is exposed. In this vicinity the sediments have been little disturbed, and are practically flat-lying. They are imperfectly consolidated, and weather very readily, so that at a short distance they resemble ordinary unconsolidated Pleistocene or Recent deposits. Overlying them at this point are at least 500 feet of lavas and tuffs of Tertiary or Pleistocene age.

These Tertiary sediments, where exposed in the amphitheatre, include at least 12 seams over 12 inches in thickness, that contain in the aggregate at least 30 feet and probably nearly 50 feet of lignite of good quality. The seams are distributed irregularly throughout the beds, occurring from top to bottom of the section.

Three samples of these lignites were taken. No. A is an average surface sample of 4 feet 6 inches of lignite exposed near the head of the left fork of Burwash creek. Neither top nor bottom of this seam was seen, the top having been removed by erosion, and the bottom not being accessible owing to its frozen condition. No. B is an average surface sample of a seam 4 feet 5 inches in thickness, which was exposed near the top of the huge amphitheatre on the sub-tributary of Duke river. No. C is an average of a number of pieces of lignite from 1 foot to 3 feet in diameter from a seam at least 3 feet in thickness outcropping in the amphitheatre. Owing to excessive weathering it was not feasible to strip this seam for a more satisfactory sample. These samples have been assayed by the Mines Branch of the Department of Mines, Ottawa, and proved to contain:

— —	A.	B.	C.
Moisture	10·2	11·2	9·8
Ash	9·1	5·4	1·6
Volatile matter	42·0	40·9	43·9
Fixed carbon (by difference)	38·7	42·5	44·7

*Brooks, A. H., "The Geography and Geology of Alaska": U.S. Geol. Surv., Prof. Paper, No. 45, 1906, pp. 237-244, and Cairnes, D. D., "The Yukon Coal Fields": Trans. Can. Min. Inst., vol. xv, 1912, pp. 365-367.

1915

Introductory Note

In the Summary Report for 1915, page 2, R. G. McConnell, Deputy Minister of Mines, includes the following brief statement on field work in Yukon Territory:

"D. D. Cairnes spent the early part of the season revising his previous geological mapping of Wheaton map-area in the southern portion of Yukon Territory and at the same time paid particular attention to the various occurrences of mineral deposits within the district, especially to those containing antimony-bearing ores which, under present conditions, are the subject of much interest. Later in the season, Mr. Cairnes made preliminary examinations of the placer and lode deposits of a district in the vicinity of Mayo, on Stewart River, Yukon Territory. The same officer, towards the close of the season, investigated the placer mining possibilities of certain streams (Scroggie, Barker, Thistle and Kirkman) leading south of Stewart River."

MAYO AREA

by D. D. Cairnes

After completing the geological mapping and investigation of Wheaton district*, the writer proceeded to Mayo on Stewart river and thence made a preliminary examination of the mineral resources of Mayo area. Not only is this one of the most important placer gold-producing districts of Yukon Territory, but valuable lode deposits have been recently discovered there from one of which shipments of high grade silver ore have been made.

The town of Mayo is situated on the right bank of the Stewart near the mouth of Mayo river which joins the Stewart 168 miles above its point of confluence with the Yukon—the mouth of the Stewart being 70 miles above Dawson. During the past summer (1915) A. G. Haultain of the topographic division of this department made a photo-topographic survey of an area that was intended to include the more valuable of the known mineral deposits along the upper tributaries of Stewart river; and it so happens that nearly all the important discoveries that have been made in this region, occur within a limited area in the vicinity of Mayo, which includes the town of Mayo, all of Mayo river, and a westerly portion of Mayo lake, the largest body of water known within the entire drainage basin of Stewart river. Thus the name Mayo** seemed the most appropriate to be applied to this particular area, and consequently in this report the term Mayo area is quite an arbitrary one, and refers to the particular portion of Yukon mapped during the past season. It extends to the south to include a portion of Stewart river, and the town of Mayo, and reaches thence northward a distance of 40 miles to include Haggart creek and Dublin gulch; it also extends to the east to include the upper portions of Duncan and Lightning creeks, and reaches thence to the west about 38 miles to embrace the mouth

* Cairnes, D. D., "Wheaton district, Southern Yukon": Geol. Surv., Canada, Sum. Rept. for 1915.

** The name Mayo was given to the lake and river by a prospector named Alexander McDonald, after Mr. Frank Mayo, one of the partners of the trading firm of Harper McQuesten and Company. McDonald prospected in this district during the summer of 1887.

of Johnson creek, a tributary of McQuesten river. Practically all of the area lies within the western portion of Duncan Creek mining district.

During the summer of 1900 R. G. McConnell made a geological examination of Stewart valley from Frazer falls down to the mouth of the Stewart[1]—Frazer falls being between 30 and 35 miles above Mayo. Joseph Keele, also, during the summer of 1904, made a reconnaissance survey and geological examination of a portion of Duncan Creek mining district, including Mayo area, and his report[2] contains a great amount of very valuable information concerning this district. During 1905 Mr. Keele continued his mapping and investigations to the east of Mayo area[3]. In addition Mr. T. A. MacLean, on behalf of the Mines Branch of this department, examined the lode deposits on Dublin gulch in 1912[4]. With these exceptions, practically no authentic information had been published concerning the geology and mineral resources of Mayo area, and Mr. Keele's reports contain practically all the information that was available concerning the geology, topography, and placer deposits of the district. A number of important discoveries had been made since 1904 and it was, therefore, decided to make a detailed geological examination of Mayo area. During the past season the topographical mapping was completed, and a preliminary examination was made of the mineral resources of the area. After the completion of the topographical map it is proposed to proceed with the detailed geological mapping, using the topographic sheet as a base.

Transportation and Accessibility

Mayo area is quite readily accessible. Stewart river generally opens between May 10 and 15, and remains clear of ice until some time in October. During the season of open navigation the steamship *Vidette*, with good passenger and freight accommodation, makes weekly trips from Dawson to Mayo, a distance of 238 miles. During the winter months, there is a monthly, and during part of the season a bi-monthly overland stage service between Dawson and Minto Bridge, a small village 10 miles north of Mayo, and situated at the junction of Minto creek and Mayo river. The distance from Dawson to Minto Bridge over the stage road is 174 miles. Mayo and Minto Bridge thus become the distributing points for Mayo area during the summer and winter seasons respectively.

The rate charged by the Side Streams Navigation Company on freight from Dawson to Mayo is two cents per pound. From Mayo, a good wagon road has been constructed by the Yukon government, to Minto Bridge, a distance of 10 miles, and from Minto Bridge government roads lead up all the main creeks, and a branch has also been extended to the recently discovered silver-lead deposit on Galena creek. The rates charged for hauling freight between Mayo and other portions of the district depend largely

[1] McConnell, R. G., "Stewart river": Geol. Surv., Canada, Ann. Rept., Vol. XIII, 1900, pp. 39A-43A.

[2] Keele, Joseph, "The Duncan Creek Mining district": Geol. Surv., Canada, Sum. Rept. for 1904, pp. 18A-42A.

[3] Keele, Joseph, "A reconnaissance survey on the Stewart river": Geol. Surv., Canada, Sum. Rept. for 1905, pp. 32-36. "Upper Stewart River region, Yukon"; Geol. Surv., Canada, Ann. Rept., Vol. XVI, pt. C.

[4] MacLean, T. A., "Lode mining in Yukon"; Mines Branch, Dept. of Mines, Canada, 1914, pp. 127-159.

on distance. An idea of the charges can be formed, however, from the following examples— one of which is a typical rate on ordinary freight out from Mayo, while the other shows a reduced rate on ore hauled in winter down to Mayo. The regular rate on freight from Mayo to Minto Bridge, and thence up Highet creek to Middlecoff's, the most important gold-producing property in Mayo area, is 2 cents per pound, the total distance being 22 miles. For hauling ore from Galena creek to Mayo, a distance of 30 miles, the rate charged last winter (1914-15) amounted to practically $20 per ton. From Mayo to the smelter in San Francisco the freight charges amounted to about $22.25 per ton.

Population

The total resident population of Mayo area during the past summer amounted to 154 white people, made up of 125 men, 12 women, and 17 children, and about 80 Indians, according to the record kept by the Royal North West Mounted Police.

General Topographical and Geological Description

Mayo area lies entirely within the Yukon Plateau physiographic province, and is mainly characterized by being subdivided by well developed, flat-bottomed, interlocking valleys into numerous, small, isolated mountain groups and areas of well dissected upland. The higher summits rise to elevations of from 5,000 to over 6,500 feet above sea-level—Mayo being considered to be 1,625 feet, and Mayo lake 2,000 feet above the sea. The former plateau surface has been largely destroyed in this district, and the shapes of the land forms, except where modified by glaciation, are for the most part dependent on bedrock structure. The district has, however, been intensely glaciated. The glacial ice, at one time, extended over practically the entire area, enveloping all except possibly the highest summits. As a result, the valley walls have become smoothed, planated, and steepened, giving to the valleys, typical U-shaped cross-sections. In addition, all the main valley floors have been deeply covered with large amounts of glacial detritus which has, in post-Glacial times, been trenched and in part removed by the streams of the district. Thus on the sides of the present stream channels, terraces have been produced, which in places are wide and are characterized by innumerable kettle holes, irregular mounds and piles, and other erratic forms typical of an old glacial floor. The entire Mayo area is drained by Stewart river and its tributaries.

The geological formations outcropping throughout the area are dominantly old schistose rocks, including mainly mica schists, quartz schists, and schistose quartzites, with also some crystalline limestones. These correspond to the old schistose rocks of the Klondike* and other portions of Yukon and Alaska, and belong to the Yukon group** which is thought to be of Pre-Cambrian age. In a few localities, these old schistose members are intruded by granitic rocks which appear to be mainly grey biotite granites, probably of Mesozoic age. Occasional dykes of rhyolite, and greenstones

* McConnell, R. G., "Report on the Klondike Gold fields": Geol. Surv., Canada, Ann. Rept., Vol. XIV, pt. B., 1905, pp. 12B-15B.

** Cairnes, D. D., "The Yukon-Alaska International Boundary between Porcupine and Yukon rivers"; Geol. Surv., Canada, Memoir 67, pp. 38-44, 1914.

resembling in general appearance andesites and diabases, also occur in a few places.

Mineral Resources

The mineral resources of Mayo area include mainly, so far as is known, gold-bearing gravels, and lode deposits, of which the gravels have, up to the present, proved to be of much greater importance. Coarse gold was found on Haggart creek in 1895, and since that time there has been more or less continuous prospecting for placer deposits within the area; and since 1898 or 1899 the district has each year yielded an important production of gold. As to the lode deposits, ore has actually been shipped from only one vein, shipments aggregating between 1,200 and 1,300 tons. This ore was high grade, and its discovery has given a great impetus to the lode mining industry of the district. The lode deposits of Mayo area, therefore, although they are not of the same immediate importance as the gold gravels, owing to the present high transportation costs and other causes, nevertheless constitute a very valuable future asset to the district.

Gold-Bearing Gravels

The Stewart was one of the first rivers in Yukon Territory to attract the attention of miners. In the year 1883, and for several years following, gold was found in paying quantities on the bars along this stream, and it is estimated that during 1885 and the two succeeding years, the yield amounted to about $100,000. Since then the production has been small, but a certain amount of bar mining is performed each year. Bars have, in the past, been worked from the mouth of Mayo river down almost to the mouth of the Stewart. Steamboat bar, which is situated about 4 miles below the McQuesten, and is the richest ever discovered on the Stewart, is reported to have yielded for some time at the rate of $140 per day per man, as worked with a rocker. The gold-bearing gravels are rarely over 2 feet in thickness, and are generally less than one foot. This extreme shallowness of the auriferous deposits, combined with the fact that in most places they were confined to small areas near the head of each bar, accounts for the rapid exhaustion of the Stewart River diggings.

Two dredges were installed on Stewart river to more rapidly work these bar deposits, and, it is believed, with the hope of obtaining coarser gold nearer bedrock. One of these dredges worked for only a few months in 1910 and 1911, and the other for only about four months altogether, during 1911 and 1912. The dredging operations proved for various reasons to be a decided financial failure.

Even yet, however, a few men engage each summer in bar mining along the Stewart between Mayo river and Lake creek; and the miner experienced in this class of work can make from $3 to $5 per day or occasionally even more, when the water is low, which is generally from about the first week in August until the freeze-up. During the past autumn (1915) about twelve men were so engaged.

In 1895 coarse gold was first discovered on the streams tributary to the Stewart, and from that time until the present, new discoveries of importance have been made from year to year, with the result that for a number of years past, the placer mining industry in the district has been one of considerable importance. Mr. George P. Mackenzie, Gold Commissioner of Yukon Territory, has estimated that to the close of 1914 the Duncan Creek mining district produced about $658,000*. Practically all of this yield came from Mayo area, except that obtained from the Stewart River bars. This estimate is thought to be very conservative, since considerable amounts of gold were mined in the early days of which there is now no official record. The main streams within Mayo area from which placer gold has been produced are Highet creek, Duncan creek, Haggart creek, Minto creek near Minto lake, and Johnson creek. These will be briefly described in order commencing with Duncan creek on the east, and proceeding toward the west.

Stream Gravels

For a clear understanding of the gold-bearing gravels of Mayo area, a general knowledge of the geological history from late Tertiary times until the present, is necessary. Before proceeding with the description of the gravels along the individual creeks, therefore, the succession of geological events within the district will be briefly reviewed as far as they have a direct bearing on the placer mining industry.

In late Tertiary times, as a result of the general uplift of the Yukon plateau, including Mayo area, a new erosion cycle was initiated, and deep V-shaped valleys were rapidly eroded, and well-defined drainage ways became again established throughout the district. This erosion period was of long duration, and continued until the streams had gradually acquired more and more gentle gradients, much more gentle, owing to their greater degree of maturity, than those traversing Mayo area at present. Consequently the gravels deposited along the stream courses of this period were very well worn and sorted, and as the softer more destructible materials were removed, they became limited dominantly to quartz and other resistant materials. The accumulations of this time are represented in the Klondike by the famous White Channel gravels, and in Mayo area by remnants of higher channels along the benches of certain streams.

This long erosion interval was terminated by the initiation of a period of deep-channel cutting which has been generally attributed to a somewhat extensive and gradual upwarp or uptilt of the land surface. This uplift apparently amounted to several hundred feet in places, and gave the streams renewed head and vigour enabling them to quickly sink deep channels in the former valley floors. The bottom of the deep channel on Duncan creek produced at this time is over 100 feet below the level of the present stream; also Minto lake is reported to be over 300 feet deep, and Mayo lake is said to be still deeper.

This period of rapid valley deepening was brought to a close by an epoch of glaciation and aggradation which followed; but it is somewhat uncertain whether or not all the aggradation is attributable to the ice invasion, as the deposits still filling the deep channels have not been carefully investigated. All of these accumulations that are exposed, including the uppermost deposits, are, however, either directly or indirectly of glacial origin. During the Glacial period, ice accumulated until all, except possibly the higher summits, became enveloped. The ice also scoured and planated the valley walls, and in places, the floors as well, and must have destroyed, to a great extent at least, the various remnants of the old stream deposits left clinging to the valley sides. Thus the pre-Glacial gravels with their

* Personal communication.

gold content were, to a great extent, transported to form erratic, unsorted, morainal accumulations. During the time of the actual occupation by the ice, vast quantities of glacial debris were irregularly deposited over the valley floors, and to some extent along the walls of the various depressions; also, great quantities of glaciofluvial sediments were rapidly deposited within the valleys, in a bedded condition. Gradually, however, with the complete disappearance of the ice, the sedimentation became less, the streams resumed more normal proportions, and instead of aggrading their courses, commenced to re-excavate channels through the accumulations deposited in the valleys. In so doing they became in many places diverted from their original channels and, in some cases, were deflected from their former valleys completely. Occasionally, they became superimposed over rock spurs, and the work of cutting down through these was of necessity very rapid in order to keep pace with erosion through the softer materials below the spurs. Thus the numerous, deep, narrow, rock canyons which characterize most of the streams of Mayo area became incised. Both pre-Glacial and post-Glacial gravels occur in places at various elevations along the walls of the drainage ways of the district, and they mark former positions occupied by the streams in the process of sinking their channels either to the deep-channel or present-channel levels.

In Mayo area, there are thus six main types of stream gravels*.

High-level gravels.
Terrace gravels—pre-Glacial.
Deep gravels.
Glaciofluvial deposits.
Terrace gravels—post-Glacial.
Present gravels.

The high-level gravels correspond to the White Channel gravels of the Klondike, and are of pre-Glacial age. In Mayo area they have been to a great extent carried away by subsequent stream action, as well as by glacial erosion, but remnants undoubtedly still remain. These gravels must have originally contained placer gold in very considerable amounts, and wherever the old channels containing them are preserved, the gold must still remain.

Deep gravels, which are also pre-Glacial, are known to occur along Duncan, Haggart, and Highet creeks, and elsewhere, but, excepting those on Highet creek, have been very slightly prospected. Where bedrock was reached on Duncan creek on No. 53 below Discovery, the gravels on bedrock are reported to have been quite rich. Gold was undoubtedly originally concentrated in the deep gravels, and it must still remain in them, except where they have been disturbed by glaciation. The deep channels on all the gold-bearing creeks will doubtless eventually be prospected and in all probability the contained gravels will be mined in many places; but up to the present it has been found impracticable to prospect these deep channels along most of the streams owing to the fact that near bedrock the gravels are not frozen, and when these thawed deposits are pierced, water comes into the shafts so rapidly that further work is impossible. No doubt this difficulty will, however, some day be overcome.

The glaciofluvial deposits include the gravels, sands, and silts deposited by streams, during the Glacial period. These deposits accumulated very

* The term 'gravels' is here used in a general placer mining sense, to include all gravels and sands occurring in the various stream channels.

rapidly; sufficiently so, at least, to aggrade the stream courses, and, therefore, it is not to be expected that any great amount of placer gold has been concentrated in them. Locally, however, on Duncan and Minto creeks and elsewhere, occasional beds of gravel having this origin, contain gold in workable quantities. These deposits are older than both the post-Glacial terrace, and the present gravels.

The terrace gravels of both pre-Glacial and post-Glacial age were deposited by the various streams in the process of sinking their channels to the levels of the deep-channels or present channels, respectively. They thus occur at various elevations along the walls of their respective valleys—the post-Glacial deposits being necessarily higher than the level of the present streams, but the pre-Glacial deposits being at any elevation above the bottoms of the deep channels. The positions of these terrace deposits are often indicated by more or less well defined terrace forms. Along Highet creek, especially opposite Rudolph pup, apparently pre-Glacial terrace gravels have proved to be very rich; and along Duncan creek, prospecting has revealed the fact that post-Glacial terrace gravels occur at various elevations above the present stream, and, in the places discovered, they contain important amounts of gold. The benches along the various creeks should thus be carefully prospected, not only for the pre-Glacial high-level channels, but also for these terrace gravels, as it seems altogether probable that a very considerable portion of the placer gold remaining in Mayo area, which can be economically mined at present, occurs in these bench deposits.

It is the gravels along the present stream bottoms, however, that have been mainly worked in this district, owing largely to the fact that they are shallow and can be relatively easily prospected. The gold in the present gravels has been for the greater part reconcentrated from higher gravels and other unconsolidated deposits, and is, therefore, liable to be somewhat unevenly distributed. These gravels are thus generally richest, just opposite or immediately below points where higher gold-bearing channels have been tapped, either by the main stream itself or by its tributaries, provided, of course, that in such places the underlying bedrock is of a nature to hold the gold.

Duncan Creek*

Duncan creek is one of the larger streams of Mayo area. It is about 14 miles in length, and follows a general southwesterly course, joining Mayo river about 6 miles below Mayo lake. The present stream flows throughout a considerable portion of its course in a decidedly constricted channel, and in places is even confined within rock canyons with almost perpendicular walls. In many places where both banks are not so steep, one of the walls is an abrupt rock scarp, showing the channel to be quite recent. On either side of the channel, a well-defined, wide-topped terrace follows along Duncan creek throughout the greater portion of its course, being most pronounced on its left side (limit). The top of the terrace has much less grade than the creek bottom, and ranges in elevation from about 200 feet above Duncan creek, opposite the mouth of Lightning creek, to over 300 feet near Mayo river. About 12 miles from its mouth, Duncan creek forks, the larger branch, called Lightning creek, continuing in the same general course as the main

* Keele, Joseph, "The Duncan Creek Mining district": Geol. Surv., Canada, Sum. Rept. for 1904, pp. 25A-29A.

creek, while the tributary, known as Duncan or Upper Duncan creek, comes in from the southeast at about right angles to this course. Commencing about 500 yards above the forks, Upper Duncan creek flows through a rock canyon about three-fourths of a mile long, with walls over 100 feet in height. A deep channel, in most places about 100 feet below the level of the present creek, follows down Lightning creek to the forks, and thence down the main or Lower Duncan creek.

The bedrock top of the terrace along Duncan creek evidently represents a portion of the old floor of the pre-Glacial stream. Subsequent to the uplift of the district, the creek cut down through this former valley bottom, and eroded the deep channel along Lightning and Duncan creeks. Later, the entire Duncan-Lightning valley was filled, largely at least, with glacial and glaciofluvial deposits to above the level of the main terrace, after which the stream began to re-excavate its course and, following the direction of least resistance, only in places became superimposed over its former channel. Thus the present creek channel with its canyons, rock scarps, and other recent features, was produced. Remnants of the old, high-level, pre-Glacial gravels probably remain on top of the terrace, but at only one point—on Makela's property—have deposits resembling them been as yet found. The glaciofluvial deposits are very conspicuous both on the benches and along the valley bottoms. Along the lower portion of Duncan creek, in particular, the stream cuts through heavy deposits of glacial and glaciofluvial gravels, sands, and silts. Deposits of glaciofluvial origin are at present being hydraulicked along Upper Duncan creek, and terrace deposits containing important amounts of gold are known to occur in places along Lower Duncan creek. The deep gravels have also been somewhat prospected. It is mainly the present stream deposits, however, that have been worked along this stream.

Gold is believed to have been first discovered on Duncan creek in 1898, in the canyon just above the forks, the discovery being made by three Swedes, a father and two sons, named Gustaveson. They were apparently very energetic prospectors, and it is claimed that, working their ground secretly and undisturbed for two or three years, they took out gold to the value of $30,000 or more. Being in such a remote and secluded locality, however, they did not think it necessary to stake their claims or record their discovery. As a result, on September 12, 1901, during their absence, a discovery was staked in the canyon by four other prospectors, Duncan Patterson, Colin Hamilton, Allan McIntosh, and Jake Davidson—Duncan Patterson giving his name to the creek. This discovery and the other claims located covered the ground formerly worked by the Swedes. During 1902, Duncan creek was staked from its headwaters to Mayo river, cabins were built on many of the claims, and active preparations were made for developing the ground. A number of shafts were sunk along Lower Duncan to a depth of over 100 feet, and 130 feet was reached on No. 104 below Discovery[2], without getting to bedrock. The depth alone would not have prevented the miners from sinking farther, but in every case they were forced to abandon their shafts on account of heavy water encountered when certain layers of unfrozen gravels were pierced. During the summer of 1903, a shaft sunk on No. 53 below Discovery, at some distance from the creek on the left limit, reached bedrock at a depth of 98 feet. During the winter, drifting

* Discovery claim was on Upper Duncan at the lower end of the canyon.

was continued toward the creek, the rock bottom yielding gold in small quantities. The water entering the drift during the progress of the work was pumped out, but the flow finally increased beyond the capacity of the pumps, and operations had to be abandoned just as good pay is reported to have been struck. The total clean-up from this working is variously reported at from $800 to $1,200. At a few other points, small amounts of gold have been obtained from Lower Duncan creek; but since 1904, very little mining has been done below the forks. Upper Duncan has, however, been worked continuously.

During last season (1915) three men were working on Lower Duncan, one man was prospecting on Parent creek, a tributary of Lower Duncan, one man was working on Lightning creek, one man was hydraulicking on the left bench of Duncan just below the forks, and five were working on Upper Duncan—a total of eleven men on Duncan creek and its tributaries.

The gravels along the creek bottom of Upper Duncan, from below the canyon upstream to No. 22 above Discovery, have been all worked over, and mining operations are at present limited to the deposits on the left bench of the creek. Last season when the creek was visited, two parties were hydraulicking on this bench. John Turner, an old-timer on Duncan creek, was working with one associate, Thomas Williamson, just below No. 8 above Discovery, and was intending to continue the working of this bench downstream. David Sparks was also hydraulicking on No. 8 immediately above Mr. Turner. Mr. Sparks has been practically continuously engaged on this creek since 1903, and holds the ground from No. 8 up to No. 17 above Discovery. He was working with two associates Sam. Rae and R. S. McLean. The gravels being worked by Turner and Sparks are mainly or entirely of glacial or glaciofluvial origin, and are coarse and composed mainly of the schistose rocks of the district. They are also fairly well bedded in places, and exhibit a certain amount of sorting, but they are also decidedly clayey in places, and include a great many foreign boulders of greenstone and pyroxenite, up to 4 feet or more in diameter. In fact, large boulders are so numerous there, that the handling of them is a serious item in the mining of the deposits. Where Mr. Turner was working, the gravel has a thickness of as much as 35 feet, and in places, on this bench, it is believed to approach more nearly 100 feet in thickness, and is nearly everywhere overlain by a considerable thickness of muck. The greater part of the gold appears to be within 10 feet or so of bedrock, but it is very erratically distributed, and is just about sufficient in amount to pay expenses with the present methods of working.

Elmer Makela was also engaged in hydraulicking on the left bench of Lower Duncan just below the forks, his property adjoining the claims of Sparks and Turner. Mr. Makela has been engaged in prospecting operations in this vicinity for about three years, and with his own labour has built a ditch for hydraulic purposes, and has installed 1,500 feet of 10-inch pipe, and a monitor, with which to explore and mine the gravels on this bench. At the point where he was working, gravels similar to those on the Sparks and Turner properties occur, but in addition a heavy bed of very different, much finer gravel was also encountered. In the top of the latter a well preserved portion of a mammoth tusk was found, this being the first mammoth or mastodon remain that is known to have been discovered on Duncan creek. This gravel deposit is as much as 100 feet thick in places and consists mainly of quartz pebbles with no large boulders. It is uniformly fine and evenly textured, and exhibits well defined bedding. In fact, the deposit very much resembles the old White Channel gravels of other localities. Insufficient work had been done, however, to show whether the gravel overlies or underlies the glacial deposits. Very encouraging amounts of gold are reported to have been obtained from prospect shafts sunk in this deposit; in the hydraulic operations, however, bedrock has not yet been reached. If the gravel proves to be a remnant of the old pre-Glacial, high-level gravels, and the central portion of the channel is preserved, important amounts of gold are to be expected.

On Lower Duncan creek, three partners, J. A. Walsh, W. L. Bramley, and John Adair were engaged in mining the creek gravels. They hold the claims from No. 4 to No. 20 above Duncan Creek bridge, and were operating mainly on No. 10. During the latter part of 1913, and the spring of 1914, they prospected the gravels of the present stream channel with a Keystone drill, the depth to bedrock of ten holes sunk being from 10 to 16 feet. Encouraging results were obtained, and mining operations were commenced. A well constructed, covered bedrock drain was built, and an efficient plant for open-cut work was installed, consisting of a boiler, engine, and self-dumping, slip scraper. The gravels being worked show very imperfect sorting, and appear in general as a jumbled mass of large boulders filled in between with sand and other fine material, boulders 3 to 5 feet in diameter being quite common. These gravels contain a great amount of material, including greenstone boulders, and hematite and jaspilite pebbles, that are foreign to the Duncan Creek drainage area, and evidently have been transported by glacial ice. In fact the present gravels along Duncan creek are dominantly a concentrate or residual product from the glacial and glaciofluvial deposits that the stream has transported and re-sorted in post-Glacial times; and the gold they contain is mainly a result of this sorting and concentrating action. When last visited during the first week in September (1915) Mr. Walsh and partners had just completed the initial dead work necessary in mining operations of this description, and had only commenced to handle the pay gravel.

A certain amount of prospecting has also been done on the left bench of Duncan creek in the vicinity of the workings of Mr. Walsh and partners, and has shown that stream gravels occur at various elevations up the face of the terrace to the top, and that in places they contain gold in encouraging amounts. Certain terrace deposits in particular between 30 and 50 feet above the present creek have been found to contain important amounts of gold. It is thus evident that these bench deposits should be more carefully prospected.

During the past summer John Salin was prospecting on Parent creek about one mile from its mouth. Parent creek is a tributary of Duncan creek, joining it from the east about 6 miles above Mayo river.

On Lightning creek a shaft was at one time sunk in the valley bottom just above the forks, and reached bedrock at a depth of 105 feet. From the bottom of this shaft, drifts were run to crosscut the deep channel at that point, but no important amounts of gold were found. This is about the only work that has been performed on Lightning creek itself, but one man, Martin Malesich, has mined for the past 6 or 7 seasons on Thunder gulch, which joins Lightning creek about 5 miles above its point of confluence with

Duncan creek. Mr. Malesich is engaged mainly in ground-sluicing, using pipe and nozzle.

It is very difficult now to determine the total amount of gold that Duncan creek has yielded. Mr. George Mackenzie, Gold Commissioner of Yukon Territory, estimates that to the close of 1915, Duncan creek has produced $55,000 and its tributary Lightning creek, an additional $2,000. Figures obtained from various old timers in this vicinity would tend to indicate that the total production considerably exceeded this amount, their estimates reaching about $75,000 for Duncan creek without including the gold obtained by the three original Swedes who are claimed to have obtained $30,000 or more. The assay value of Duncan Creek gold is generally between $16.50 and $16.60 per ounce.

Haggart Creek

Haggart creek is one of the principal tributaries of the McQuesten, having a length of over 20 miles; it has a general southerly to southwesterly course, and joins the south fork of McQuesten river, about 13 miles above its confluence with the north fork. The general characteristics and geological history of Haggart creek are much the same as those of Duncan creek. The present stream follows a recent, somewhat constricted channel; and an older deep channel also has been encountered in shafts sunk both above Dublin gulch, and along the lower portions of Haggart creek. One shaft to bedrock above Dublin gulch is 90 feet deep, and another near the mouth of Lynx creek is 140 feet deep. Stream gravels are also known to occur on the benches along Haggart creek, but these have been very slightly prospected; however, gravels containing important amounts of gold have been found on the left bench, several hundred feet back from the stream, and only a few claims below Dublin gulch. Glacial and glaciofluvial deposits at one time filled the valley bottom to above the top of the present main terrace or bench, but have since been transported to a considerable extent by the present stream. Vast amounts of boulder-clay and related deposits still remain, however, and are to be seen wherever sections of the superficial, unconsolidated deposits are exposed.

The only gravels that have been actually mined along Haggart creek are those occurring along the present stream channel. They are shallow, in most places, being less than 10 feet thick along the creek bottom. They consist dominantly of the schistose rocks of the district, but include also boulders and pebbles of greenstone and granitic rocks. These gravels, however, nowhere contain such large boulders as are contained in the gravels along Duncan creek. The largest boulders are generally between 1 foot and 3 feet in diameter and those exceeding 1 foot are somewhat exceptional. Along both sides of the creek's present course the gravels are frozen throughout, but in the creek bed, they remain thawed near bedrock even during the winter. Drifting operations are, therefore, possible only along the sides of the stream, the creek bottom being worked in summer by open-cut methods. The gold occurs mostly close to or in the bedrock, and is mainly limited to 2 feet or less of gravel and the underlying 3 feet of bedrock, 2 to 3 feet of bedrock being taken up in places in the course of mining operations.

The gravels at present being worked along Haggart creek are in places overlain by a few feet of boulder-clay, but sufficient evidence has not yet been obtained to determine whether the boulder-clay was originally deposited over these gravels, or has since slid over them from the banks. If the boulder-clay was originally deposited over the gravels, they must represent a high pre-Glacial channel, approximately 100 feet above the lowest known channel in Haggart creek; in which case it follows that along the portion of the creek where mining is being prosecuted, the present stream has by chance not only become superimposed directly over an old channel, but has succeeded in re-excavating its course down to practically the same level as this former depression.

Gold is reported to have been first found on Haggart creek in 1895*, and in 1896 the creek is known to have been prospected by Thomas Nelson who found gold in the canyon 4 to $4\frac{1}{2}$ miles from the mouth; after him the stream was named Nelson creek. In the same year Thomas Haggart built two cabins on the creek, and one on Dublin gulch, from which to prospect and mine. In 1898 Thomas Haggart, Thomas Nelson, Peter Haggart, and Warren Hiatt started from Dawson for Nelson creek, but en route separated into two parties, and Peter Haggart and Warren Hiatt, reaching their destination first, staked Discovery, and renamed the stream after Peter Haggart. Since then there has each year been more or less mining and prospecting along the creek.

During the summer of 1915, about 14 men were engaged in placer mining on Haggart creek, and an additional 3 men were working on Dublin gulch, a tributary which joins it from the northeast about 14 miles from its mouth. The properties being worked on the creek all lie between Dublin gulch and No. 20 below Discovery—the upper end of Discovery claim reaching up to just about the mouth of Dublin gulch. Some prospecting was done in the past above Dublin gulch, and a number of shafts were sunk, but no pay gravels were found. The lower portion of Haggart creek, also, has been prospected, but no one has worked there since 1912.

The lowest operations on Haggart creek during 1915 were being conducted by three partners, C. E. Kinsey, John Mawhinney, and C. E. Merriman, who hold nearly all the ground from No. 11 to No. 20 below Discovery, and also 1,500 feet up Gill gulch. They have built a ditch about three-fourths mile long, including 300 feet of flume, which takes water for mining purposes from Claim No. 9 below Discovery, have constructed a covered bedrock drain about 1,200 feet long, and a 600-foot waste ditch, and have installed a boiler, engine, and self-dumping scraper. When visited during the latter part of August they had completed this installation and removed a certain amount of overburden, and were commencing to handle their pay gravel.

W. Abbott, N. Abbott, and W. Portlock, who own about five claims from No. 4 to No. 8 below Discovery, were also engaged in open-cut work, employing three men in addition to themselves. These partners have been mining on this property practically continuously for about five years, drifting mainly along the right rim of the creek, and open-cutting in the creek bed, the open-cut operations being possible only in summer. To work their property they have built a ditch about 2,000 feet long to supply water for washing the gravels, and also have constructed a covered bedrock drain about 600 feet long. They have also installed a boiler, engine, and self-dumping bucket outfit, an efficient plant for this class of mining. The pay gravels are there in most places from 50 to 70 feet wide, but in some

* Op. cit.

places are considered to be nearer 200 feet in width; the gravels along the creek bed have an average thickness of from 6 to 7 feet. The ground being worked is believed to average from 30 cents to $1 per square foot of bedrock.

Three partners, John Maynard, Fred R. Gill, and A. Jahnke, who hold claims Nos. 1, 2, and 3 below Discovery, have also been working their ground for about seven years. During most of this time, they were engaged in winter drifting along the right rim of the creek, but during the past summer (1915), open-cut operations were commenced in the creek bottom. These partners have built a bedrock drain, about 1,000 feet long, and a ditch, to supply the necessary water for mining purposes. They have also installed a car into which the gravel is shovelled, and which is pulled up an incline and automatically dumped. The power installation on this property is both unique and economical: instead of the customary boiler, in a locality where fuel is somewhat scarce and expensive, they have installed an overshot waterwheel which supplies the necessary power for hoisting. The ground here is not thought to average more than 50 cents per square foot of bedrock along the creek bed, but along the right rim in places it runs up to 70 or 75 cents per square foot.

Three other partners, Louis Cantin, Frank Cantin, and Frank McKenna hold Discovery and three adjoining claims, which they have worked since 1909. During the past summer, only the Cantin brothers actually worked on their claims, and their operations were mainly limited to hydraulicking along the right rim of the creek, where the gravels are in most places from 6 to 10 feet in thickness. The creek bottom will probably be worked later, as the gravels there are thought to be probably richer than those being at present mined. However, hydraulicking along the side of the creek can be very cheaply performed, as the bedrock dips from this rim down to the middle of the channel, and so drains itself, and makes unnecessary the expensive bedrock drain, maintained in working the thawed gravels in the creek bottom. Also these slightly higher rim deposits can be moved to a great extent with the nozzle, so that very little pick and shovel work is necessary.

On Dublin gulch*, John Suttles has been engaged in placer mining since 1898, and has been holding about 2,500 feet of ground near the mouth of the creek. His operations have been mainly restricted to hydraulicking the present stream gravels along the creek bottom, these deposits being in most places from 6 to 20 feet in thickness.

The cost of mining along Haggart creek varies considerably, depending upon a number of factors; two of the most important are the thickness of the gravels, and their location—whether they are in the creek bed and partly thawed, or in the frozen zone to one side of the present channel. For working the partly thawed gravels in the creek bed, by means of a self-dumping equipment, when a bedrock drain has to be maintained, the actual operating costs average from 30 to 35 cents per square foot of bedrock, but if the cost of installation and the maintenance of the plant be included, the total cost amounts to about 50 cents per square foot. Hydraulic operations along the creek rim as performed by Cantin brothers, can be carried on for about 10 cents per square foot.

The gold production of Haggart creek is estimated by Mr. George Mackenzie, Gold Commissioner of Yukon Territory, to be about $47,000,

*Op. cit.

which checks very closely with the figures obtained from various old-time miners familiar with this district from 1898 until the present. The gold from Haggart creek generally assays about $18.45 per ounce, and that from Dublin gulch about $17.80.

Minto Creek*

Prospecting and mining were carried on along Minto creek a number of years ago, and during the last few years Otto F. Kastner and James A. Scougale have done some work on the left bench of the creek a short distance below Minto lake.

During the period of deep-channel cutting in Mayo area, a deep, steep-walled depression was incised through the valley now occupied by Minto lake, and persisted along the upper part of the present valley of Minto creek; not far below Minto lake, however, this old channel apparently swung to the left of the present stream course. It is known that the channel must be very deep, in places 300 feet or more below the level of the present valley bottom, as Minto lake is over 300 feet deep, and shafts have been sunk in the valley of Minto creek to depths of from 70 to 130 feet without reaching bedrock. This deep channel cutting was followed by a period or periods of aggradation during which the deep depression was rapidly filled with various kinds of sediments to above the elevation of the terraces that extend along the side of the present Minto creek at heights of over 300 feet above the level of the stream. Following this aggradation interval which was related to and included the Glacial epoch, the present Minto creek began to trench its channel down through the deposits in its valley. This work of re-excavation was very rapid at first, but gradually the stream channel reached a somewhat graded or aggraded condition, and the creek has now become a small sluggish stream.

Previous to the purchase of the Kastner-Scougale property a few years ago, some prospecting had been carried on, but the greater part of the mining and development has been done during the past three years, while the property has been under the management of John A. Ross. The operations on the property have been limited to hydraulicking and to work connected with that class of mining. Three ditches, having an aggregate length of $8\frac{1}{4}$ miles, have been dug, which bring water for hydraulic purposes from McIntyre, McLagan, and Turnip creeks; and monitors, piping, sluice-boxes, and other equipment comprising an efficient hydraulic plant, have been installed.

The hydraulic operations have exposed a section which includes bedded sands, gravels, and clays, and also boulder-clay, having an aggregate thickness of more than 200 feet. The lowest of these unconsolidated deposits exposed, rests on a low rock rim about 40 feet in elevation above Minto lake, and the uppermost beds are some 210 feet higher. These beds are in places nearly flat-lying, but for the most part dip toward the creek at angles rarely exceeding 10 degrees. For about 150 feet above the lowest beds exposed in the hydraulic cuts, bedrock has been encountered, and is seen to rise abruptly behind them, forming a rock wall which constituted the valley side just previous to the period of aggradation during which they were deposited. Bedrock had not been encountered above this point when the property was visited in September last (1915). The bedrock formations

* Op. cit.

consist dominantly of very old, probably Pre-Cambrian, schistose rocks which are mainly quartzite schists, but embrace coarser textured members, including some sheared conglomerates. These rocks are very micaceous in places and grade into mica schists. This schistose group of rocks is cut and invaded by reddish granite porphyry which is somewhat extensively exposed in the hydraulic cuts, and is thought to be of Mesozoic or early Tertiary age.

A small amount of gold was found on the low, bedrock rim above mentioned, and occasional bunches or pockets of gold-bearing gravels have been found erratically distributed throughout the uppermost sands which are evidently lake deposits, and are extensively developed along the top of the main terrace bordering Minto creek in this vicinity. Apparently these bunches of gold-bearing gravels were not originally deposited where they now occur, but represent bodies of gravel that were transported *en masse* by glacial ice, possibly by icebergs. They are, therefore, not very extensive or important as a source of placer gold. The only gravel so far encountered on this property, which gives any promise of constituting a workable deposit of any considerable extent, is a bed about 20 feet in thickness which occurs near the top of the workings. This is overlain by about 20 feet of fine, partly consolidated, bedded sands which are in turn covered by the sands above referred to, which contain the irregular bunches of transported gravels. The boulders or pebbles of this 20-foot bed of gravel are well rounded, and the gravel generally resembles a typical bar deposit. This gravel deposit is claimed by Mr. Ross to contain gold in sufficient quantity to pay well for mining, and it is hoped that it will prove to be sufficiently extensive to yield gold enough to at least pay for the past installation, development, and mining operations.

Highet Creek*

Highet creek is one of the small tributary streams draining the portion of deeply dissected upland lying between Mayo and McQuesten valleys. It has a general easterly to southeasterly course, is about 8 miles in length, and joins Minto creek about $2\frac{1}{2}$ miles below Minto lake, or 7 miles above its point of confluence with Mayo river at Minto Bridge. The present mining operations on Highet creek are confined to about 3 miles of the creek, the uppermost workings being about opposite the mouth of Rodolph pup, which is 13 miles from Minto Bridge measured along the wagon road. The creek has been prospected in the past, both above and below this section, but little if any actual mining has been done.

Great amounts of boulder-clay and gravel, overlain by sands or silts, were deposited in Highet valley during the Glacial period; and since the disappearance of the ice, the present stream has been re-excavating its channel in these accumulations, but has not as yet succeeded in reaching its pre-Glacial level. Thus along the portion of the creek at present being worked, the stream is flowing in a somewhat constricted channel bordered on either side by banks and terraces of boulder-clay, gravel, slide material, sand, and silt, and remnants of these deposits are still clinging to the valley walls up to an elevation of 300 feet or more above the present creek bed.

The present mining operations are almost entirely concerned with the

* Op. cit.

gravels in the creek bottom, although terrace deposits along the right bank of the creek have been mined in the past and are still being worked to a limited extent. The gravels being mined in the creek bottom underlie boulder-clay and are evidently of pre-Glacial age; the portion of the present stream now being worked has thus quite fortuitously become superimposed almost directly over its pre-Glacial position. The gravels being mined are dominantly coarse and include numerous large boulders of schist and granite. In places, also, they are fairly regular and are quite well sorted, but nearly everywhere both the gravels and the underlying bedrock exhibit evidence of having been formerly buried under an enormous weight of glacial ice which moved down Highet valley. The ice in places cut its way down to bedrock as evidenced by glacial striæ and grooving, but at other points, apparently, it over-rode the gravels which in places have lost all definite arrangement, and even include masses of soft bedrock that have been pushed several feet up into them. In places, the gravels are quite compactly cemented with a clayey matrix and grade up into the overlying boulder-clay. The gold is, therefore, very erratically distributed, at some points occurring in the bedrock or within a few inches above it, and at others, in rearranged gravels lying several feet above bedrock.

Terrace deposits opposite the mouth of Rodolph pup have also been mined and have proved to be quite rich. They also appear to be pre-Glacial in character, and to represent position, occupied by the pre-Glacial stream in the process of cutting its way to its lowermost position.

Along Highet creek there appears to be very little frozen ground adapted to drifting, which is practically the only method that can be employed for mining these gold-bearing gravels in winter. Consequently the mining on the creek is done almost entirely during the summer months.

Gold was first actually mined on Highet creek in 1903, but the creek is named after Mr. Warren Hiatt, who found gold on or in the vicinity of claim No. 105 several years before 1903—the present spelling of the name having been adopted through an error made by the original recorder. In June, 1903, Rodolph Rosmusen, Warren Hiatt, and J. D. McRay staked claims on the upper part of Highet creek. Soon after George Edwards, Fred Wade, and others located; and in a short time these early stakers commenced actual mining operations. Since that time Highet creek has had an important gold production each year, and has to date yielded more gold than all the rest of Mayo area. Previous to June, 1903, nothing was known concerning the placer deposits of Highet creek, except as a result of Hiatt's early discovery; the lower part of the creek had been stampeded and staked, but no gold had been found.

The highest point at which mining was being performed on the creek during the past summer was on claim No. 108, nearly opposite the mouth of Rodolph pup. There, Frank McKenna, who also owns claims Nos. 106, 114, and 116, was engaged in hydraulicking the terrace gravels along the right bank of the stream. At this point two well defined upper channels are exposed, which contain typical terrace gravels which are well exposed and have been worked from claims Nos. 100 to 109, inclusive. These terrace deposits appear to run out into the present creek valley above No. 109, and a short distance below No. 100. On No. 108, bedrock underlying the lower of the two upper channels is about 17 feet in elevation above the level of the present creek, opposite, or about 35 feet above the bottom of the deep channel below the present creek. The higher of the upper channels is 8 feet above the lower. Important amounts of gold have been found on both of these terraces, but the upper one was much the richer. The total amount of gold that has been obtained from these terrace deposits is now difficult to correctly estimate, but from the best information available, it would appear to be between $100,000 and $140,000, and practically all of this came from claims Nos. 100 to 109 inclusive, the claims being 250 feet in length.

Mr. Elmer Middlecoff owns and mines about 2 miles of the creek next below. His operations have been and still are the largest in Mayo area. The mining equipment has been largely designed by Mr. Middlecoff to suit the peculiar conditions met with, and is both novel and efficient. One of the main considerations in connexion with any plant on this creek is to have it so designed as to make the best use of the limited amount of water available. On the Middlecoff property a large automatic dam has been constructed which is used for sluicing off the overburden during high water in spring. A specially designed self-dumping scraper has been installed, which is used largely for stacking the boulders encountered in sluicing the gravels. The gravels are conveyed into a line of sluice boxes by monitors. The sluice boxes are made of sheet steel and are lined along the sides with boards or slabs, the riffles in the bottom being of flat stones selected from the tailing piles. A clam-shell steam shovel disposes of the tailings, picking them up at the lower end of the sluice boxes and stacking them to one side. During the past summer, Mr. Middlecoff employed throughout the season an average of about eleven men, and mining operations were continued night and day. The average depth to bedrock was about 16 feet, and it was found that the gravels could be mined profitably for a width of 100 feet and in exceptional places to widths up to 200 feet. Mr. Middlecoff states that in his seven years mining in this vicinity, he has obtained gold to the value of nearly $250,000.

Adjoining Mr. Middlecoff's property, downstream, is a group of claims owned by a partnership, locally known as the 'Little Gugs', made up of Geo. H. Miller, G. P. Godbout, M. P. Lindquist, Rodolph Rosmusen, and Charles Rockney. The 'Little Gugs' own all except three of the claims from No. 60 to No. 75, and have been working this property for the past five summers. No mining has been performed below No. 60. Until the past summer (1915) the partners worked their claims by means of an automatic dam and a self-dumping bucket equipment. The automatic dam, which is 12 feet high and has a gate 12 feet wide, was used to sluice off the overburden during high water in the spring, and later in the season the underlying pay gravels were conveyed to the sluice boxes by means of the self-dumping bucket which was operated by an 8-horsepower engine and boiler. Last summer a self-loading, self-dumping, one-yard bucket known as a drag-line, cable-way excavator was installed, which is operated by a 30-horsepower engine. As the new equipment was late in arriving no actual mining had been done with it when the claims were visited about the end of August. The owners of the property have worked 750 feet of the creek bottom, and state that in so doing, they recovered gold to the value of over $80,000. The average depth of material worked was from 27 to 35 feet, and the width of the best pay was about 80 feet, to either side of which the gold becomes gradually less in amount.

The gold from Highet creek is heavy and well rounded, and that from the 'Little Gugs' property is about one-tenth composed of nuggets worth from $1 to $10 each. The gold generally assays from $17.20 to $17.28 in gold and 7 to 8 cents in silver per ounce. It is difficult to form a close estimate of the total production of the creek. It would seem, however, from the information available, that it must amount to nearly $500,000.

Johnson Creek

Johnson creek is a small stream about 6 miles long, which heads with Highet creek, but flows in an opposite or northwesterly direction into the McQuesten, joining that river about 4 miles below the forks, or approximately 40 miles above its confluence with the Stewart. The valley of Johnson creek is a typical U-shaped depression, with the valley bottom and walls verdure and forest clad to the summits on either side.

Johnson creek is at present a 'new creek', to use a term commonly applied in Yukon to a creek which has been recently stampeded and staked after gold has been found in it, and a discovery claim located. The stream is named after F. Johnson who prospected it and staked a Discovery claim in the lower part of the valley in the autumn of 1898. As a result of this discovery thirty-eight men are reported to have been on the creek that autumn, most of whom wintered there. The attempts that were made to prospect the stream at that time were unsuccessful, owing to the fact that unthawed ground was encountered in the shafts before bedrock was reached, and water consequently came in so fast that the sinking had to be abandoned. Since that time practically no prospecting had been done on the creek until the autumn of 1914. The earliest discoveries on Johnson creek were, however, made even before 1898. Johnson had found gold there some time previous to the autumn when he staked his Discovery; also in 1894 two Garrison brothers found gold on this stream and returned to Dawson for an outfit; but they remained there and later located claims on Eldorado, and not long afterwards died in the Klondike from fever.

In the autumn of 1914, Ogden Pickett Thomson moved to McQuesten valley, and built a cabin at the mouth of Johnson creek, from which to prospect the surrounding neighbourhood. He commenced work on Johnson creek, on what is now his Discovery claim, in November, and on January 1 first found pay gold. The creek was stampeded and staked during the latter part of January and in February. The discovery was thus due entirely to the untiring energies of Mr. Thomson, an old-timer who has been in Yukon continuously since 1898. When visited about September 1 (1915), he owned Discovery claim and No. 1 below Discovery.

Up to September, 1915, no actual mining had been done on the creek except on Discovery claim. Several holes or shafts had been started above Discovery, but in each case unfrozen ground was encountered, and sinking had to be abandoned. On Discovery claim the ground was frozen to bedrock along the edge of the creek where the mining was performed, but it is probably unfrozen under the creek channel. Mr. Thomson had leased portions of his ground, and about eight men were working on Discovery claim last summer. Three shafts, only a few feet apart, had been sunk on Discovery claim on the right side of the creek, in each of which bedrock was encountered at from 20 to 26 feet; and from the bottom of these shafts, the gravels on bedrock were drifted out, hoisted by wind-lass, and washed, the ground being thawed with steam points. The deposits exposed in these workings are largely of glacial origin, and consist mainly of coarse gravels containing numerous large boulders, and cemented by a clayey matrix. These deposits exhibit in most places very imperfect sorting, and many of the boulders are on edge. In places, close to bedrock, finer, heavier, more regular gravels occur which are gold-bearing.

The gold obtained from Discovery claim is massive, somewhat rough or angular, and fairly coarse, many single nuggets worth $2 to $3, and one valued at $8 having been obtained. The first gold recovered assayed $16.78 in gold and 5 cents in silver per ounce. Up to September 1 (1915), the total gold obtained from Johnson creek amounted to about $800. The results so far obtained from the creek have been very encouraging and should give a stimulus to placer mining on other creeks in the neighbourhood.

Lode Deposits

Lode deposits of various types are known to occur at a number of points throughout Mayo area. Most of the prospectors in the past, however, have been in search of placer deposits, very few quartz prospectors having as yet visited the district. In addition, throughout the greater part of the area, there is a heavy mantle of superficial deposits, which obscures the underlying bedrock in most places, and renders prospecting for lode deposits very difficult and uncertain. The discoveries that have been made were mainly due to accident, or to the deposits being exposed along some stream cutting. This area cannot thus be considered to have been more than very slightly prospected, and many other valuable mineral deposits may yet be found within it.

The lode deposits that have been discovered within Mayo area, include mainly a rich silver-lead vein on Galena creek, and a number of gold-bearing veins on Dublin gulch. Other veins are known to occur carrying gold, silver, lead, and zinc minerals; but in most cases they have not been at all developed, and very little is known concerning them. Also on Highet creek and elsewhere, scheelite is frequently obtained in the concentrates in placer mining, indicating that deposits of this mineral occur in the vicinity. As scheelite and other tungsten ores have taken on increased value and importance since the outbreak of the war careful search should be prosecuted for deposits in which they occur.

Galena Creek

The silver-lead vein on Galena creek outcrops in the canyon about 3 miles from the mouth of the creek. Galena creek joins the south fork of the McQuesten approximately 25 miles above its confluence with the north fork. The Galena Creek property is reached by means of a wagon road constructed by the Yukon government, from Minto Bridge to the mine workings, a distance of about 20 miles.

The Galena Creek vein is believed to have been discovered and staked by H. W. McWhorter and partner about the year 1906, but the claim was afterwards allowed to lapse. The deposit was relocated in 1912 or 1913 by Mr. McWhorter who gave a lay [lease] on the ground to Jack Alverson and Grant Hoffman. These layees [lessees] did the first real development on the property, and proved it to be of importance. They shipped 59 tons of ore to the smelter at Trail, B.C., the smelter returns for which amounted to $269 per ton, in gold, silver, and lead, the gold being very low, but the lead amounting to 45 per cent. In the spring of 1914 the property was acquired by Thomas P. Aitken and Henry Munroe, Mr. Aitken being the principal owner. During the winter of 1914-15 these owners shipped 1,180 tons of ore to San Francisco. The smelter returns for this shipment, according to a statement kindly furnished by Mr. Aitken, included $3 per ton in gold, and for about half of the ore, 39 per cent lead and 280 ounces of silver, and for the other half 23 per cent lead and 260 ounces of silver per ton.

The vein outcrops in the walls of the canyon on Galena creek, but to either side along its strike is not exposed, being covered with a heavy mantle of drift. Thus all that is known concerning the vein is derived from the mine workings and the exposures in the canyon which at this point has a depth of about 70 feet. The vein occurs in a fissure, or in places really in a compound fissure traversing old altered sediments probably of Pre-Cambrian age. These where exposed in the canyon are greyish to greyish-green, schistose, quartzitic, sericitic rocks which in places occur in heavy massive quartzite beds with relatively little sericite, but also grade into more finely laminated phases that become typical sericite schists. All these rocks have been much contorted and broken, and contain a great amount of secondary quartz which occurs in lenses, stringers, and irregular bunches. These have been deposited for the most part along the planes of schistosity of the enclosing rocks; but in places stringers and veinlets occur intersecting the foliation surfaces at various angles.

The vein strikes about astronomic north 65 degrees east and dips to the southeast at angles ranging generally from 55 to 80 degrees, although in places it has an almost vertical attitude. The extension of this vein on the northeast side of the canyon comprises really a fault zone about 5 feet in thickness, which includes crushed and sheared wall rock interspersed with small quartz stringers, the most prominent of which is 6 to 8 inches in thickness and is only slightly mineralized. An adit 100 feet long has been driven in on this zone from an elevation only a few feet above the creek level, and along this adit, the quartz and all other evidence of mineralization gradually disappear, until at the end, there is only about 2 feet of barren, sheared, country rock.

On the southwest side of the canyon, the vein is very highly mineralized chiefly with galena and ruby silver, although a certain amount of iron pyrites also occurs, and in one place a band of zinc blende about 2 inches or even more in thickness, which contains about 30 per cent zinc, follows the foot-wall. An incline shaft on the vein had been sunk 185 feet below the level of the upper edge of the canyon walls, when the property was visited about the middle of August (1915); and from this incline, stopes had been opened up from which the ore was being mined. In the mine workings, one main shoot of highly mineralized rich ore had been encountered, which in most places consists mainly of galena and ruby silver with only subordinate amounts of quartz gangue; it is claimed to average over $150 per ton in gold, silver, and lead. This shoot dips to the northeast along the vein, is about 30 to 35 feet long, and has been found to persist downward to at least the level of the bottom of the incline, the lowest point reached by the mine workings in August. Near the middle, the shoot is 40 to 48 inches thick, but it narrows to 6 or 8 inches at the edges.

Another shoot or pocket of ore was encountered to the southwest of the main shoot, in a short drift run to the southwest from the bottom of the incline, during the writer's visit, and from the face of this drift two samples were taken. No. 1 was an average of the upper 22 inches of the vein, which there consisted of quartz containing considerable ruby silver. No. 2 was an average of the remaining 14 inches of the vein which was composed mainly of galena and ruby silver. These samples were assayed* and found to contain:

Sample No.	Gold		Silver		Total value per ton gold and silver	Lead percentage
	Ozs. per ton	Value per ton	Ozs. per ton	Value per ton		
1	Trace	.....	306·00	$153.00	$153.00	2·53
2	0·16	$3.20	553·44	266.72	269.92	40·90

The property is equipped with two 40-horsepower boilers, a compressor, pumps, and other machinery necessary to constitute an efficient plant for mining, hoisting, and pumping. Comfortable buildings have been erected and an assay laboratory established with a competent assayer in charge.

The cost of freighting the ore to Mayo over the snow in winter has been about $20 per ton; from Mayo to San Francisco the freight charges amounted to approximately $22 per ton; and the cost of treatment there was about $20 per ton, a total of possibly slightly over $62 per ton for freight and treatment.

As the vein is deposited along a well-defined fault fissure showing considerable displacement, it is certain to be quite persistent, and it is more than probable that other valuable shoots will be found within the vein. In a vein of this description the occurrence, unaccompanied by others, of one shoot so highly mineralized and so persistent vertically as this one, would be almost unparalleled in the history of ore deposits. Furthermore, fissure veins rarely if ever occur singly. In the various parts of the world where similar mineralized fissures have been investigated, they have been found almost without exception to occur two, three, or more together in fairly close proximity to each other; and since in the vicinity of Galena creek, bedrock is nearly everywhere covered with a heavy mantle of overburden, it is probable that other valuable veins will yet be discovered in the neighbourhood when the concealed ground is prospected. If future development exposes a reasonably large tonnage of ore, the owners would then be justified in erecting a concentrating plant on the property, which would greatly reduce freight and treatment charges, and would allow of grades of ore being treated which it does not now pay to ship.

Dublin Gulch

A number of mineral veins have been discovered in the vicinity of Dublin gulch, a small stream about 4 miles long, which is a tributary of Haggart creek and joins it from the northeast about 14 miles from its mouth. The veins so far found are for the most part distributed throughout a southwesterly trending belt, 2 to 3 miles in length and less than one mile in width, which, commencing near Haggart creek, extends up the left side of Dublin gulch about 2½ miles, and there crosses over to the right side of the gulch.

The geological formations in the vicinity of Dublin gulch include mainly old, probably Pre-Cambrian, schistose rocks, and granitic intrusives of

*All assay returns given in this report were obtained from the Government assay office, Whitehorse, Yukon.

possibly early Mesozoic age. The schistose members consist mainly of metamorphosed quartzites which, however, pass by a gradual transition into mica and sericite schists. All these older rocks are much distorted, sheared, and faulted. In the vicinity of Dublin gulch they have also been somewhat extensively invaded by the granitic intrusives, and it is near the contact of the older rocks with these later intrusives, that the veins occur, certain members being in the one formation, and certain ones in the other, some even passing from one rock to the other with little apparent change in mineralization. The veins in the granitic intrusives, however, are naturally much the more regular in form, as fractures traversing a firm, massive rock of this kind are much simpler and more persistent than those in the old, contorted, sheared, foliated schists.

The veins range in thickness from one inch or even less to 3 to 4 feet, but well mineralized deposits more than 2 feet thick are exceptional. They consist dominantly of a quartz gangue which is mineralized, chiefly with arsenopyrite (mispickel) and some iron pyrites; all the better mineralized portions of the veins, and particularly those found to carry important amounts of gold, are heavily stained with a greenish arsenate of iron. No attempt was made to thoroughly sample these veins to determine their gold content throughout, as Mr. T. A. MacLean had previously sampled all these deposits on behalf of the Mines Branch of this Department*. Occasional samples were taken, however, of typical portions of the veins wherever they were exposed. These samples in most cases were found to contain from $2 to $16 in gold per ton, with a general average of between $8 and $9. One sample from the Olive vein, however, ran $44.70 in gold. The silver content rarely exceeds one ounce per ton. A decided surface enrichment in gold occurs in connexion with these veins, the oxidized portions containing important amounts of free gold which can be recovered by panning.

It is evident from the sampling that has been done, that none of the deposits are of sufficiently high grade to pay for shipping to outside points for treatment, without previous concentration. If a small concentrating mill were erected in their immediate vicinity, however, considerable portions at least of some of the veins would pay for treatment, and the oxidized zone of many of them would yield important amounts of gold.

The various veins examined will be described in order, commencing near the head of Dublin gulch and proceeding downstream.

On the *Carscallen claim* two adits or drifts have been driven along the right side of Dublin gulch about 2½ miles above its mouth, on a claim owned by Frank Carscallen. The lower adit was caved in when visited, but is said to be about 25 feet long and to be driven on a promising vein. The upper adit, which is only about 150 feet from the creek bottom, is 90 feet long, and is driven in on a vein which strikes south 60 degrees west (astronomic), dips at about 60 degrees to the southwest, and has a thickness of from 6 inches to 3 feet. In addition to this main vein, a secondary parallel vein, having a thickness ranging from an inch to about 18 inches, is exposed along the northeast side of the drift. This secondary vein has a flatter dip than the main vein, and inclines toward the latter, apparently joining it a few feet below the floor of the drift. These veins occur in fissures in a greyish granitic rock which is considerably altered and decomposed for 2 or 3 feet on each side

* MacLean, T. A., "Lode mining in Yukon": Mines Branch, Dept. of Mines, Canada, 1914, pp. 127-159.

of them. The vein filling consists dominantly of quartz which is well mineralized in most places, chiefly with arsenopyrite (mispickel) and with some iron pyrites, and is heavily stained with a greenish arsenate of iron. The ore material in the secondary vein is very irregularly distributed and broken, and occurs largely as erratic, broken bunches. Two samples were taken from this adit.

No. 1 is an average of the main vein at the breast of the drift, where it has a thickness of 12 inches. No. 2 is an average across the main vein about halfway in the drift, at which point the vein has a thickness of about 3 feet. These samples were assayed and found to contain:

Sample No.	Gold		Silver		Total value per ton gold and silver
	Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
1	0·52	$10.40	4·48	$2.24	$12.64
2	0·42	8.40	3·35	1.67	10.07

The *Olive claim* is located on the left side of Dublin gulch, the main workings being 1,700 to 1,800 feet from Dublin gulch, and about 2 miles from Haggart creek, measured as the crow flies. The claim is also on the right side of Olive gulch, a small tributary of Dublin gulch, entering it from the left, about 2 miles above Haggart creek. The Olive claim was staked about the year 1908, has been since surveyed, and is owned by Robert Fisher. A well mineralized vein has been discovered on this property on which an adit or drift 100 feet long has been driven. This vein strikes north 74 degrees east (astronomic), dips 70 to 75 degrees to the southwest, and throughout the drift has a thickness of from 8 to 14 inches, being in most places about 12 inches thick. The vein occurs in a fissure in granite which is altered and somewhat decomposed and soft for 2 to 3 feet on each side. The vein material consists mainly of quartz which is heavily mineralized mostly with arsenopyrite. Some pyrite also occurs, and the vein filling is for the greater part heavily stained with a greenish arsenate of iron. Two samples were taken from this adit. No. 1 is an average across the vein at the end of the drift, where the vein has a thickness of 12 inches. No. 2 is an average across the vein where exposed in the roof of the drift at a point about halfway into the breast, at which point the vein is 10 inches thick. These samples were assayed and found to contain:

Sample No.	Gold		Silver		Total value per ton gold and silver
	Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
1	2·10	$42.00	5·40	$2.70	$44.70
2	0·80	16.00	1·70	0.85	16.85

A second parallel adit was also commenced a few feet above and to the left (northwest) of the one just described. When well under cover, however, this upper adit turned toward the lower workings, and encountered the vein there exposed in about 70 feet, and drifted along it for 20 feet.

The *Stewart-Catto group* embraces one unsurveyed fraction, and five claims and one fraction that have been surveyed and for which application has been made for crown grants. These claims are all located on the left side of Dublin gulch between Olive and Stewart gulches, and are owned by J. S. Stewart and Dr. William Catto. The claims have been held for about seven years, most of them having been staked in 1907; the Victoria claim of this group was the first claim staked on Dublin gulch. At least eight veins have been discovered on this property, but most of the development work has been expended on three of these which are designated the Cabin, Victoria, and Green veins. These three and a fourth exposed in the underground workings on the Victoria claim, were the only ones examined by the writer. The cuts, trenches, or other works exposing the other veins had so caved in that the veins could not be seen.

The Cabin vein, so called because it is situated just above Mr. Stewart's cabin, is exposed on the surface by a line of open-cuts. In addition, an adit or crosscut has been driven which encountered the vein after a distance of 132 feet. The vein strikes about south 44 degrees west (astronomic) and dips to the southeast at an average of about 65 degrees. It occurs in a fissure in the older schistose rocks of the district, and where encountered underground has a thickness of 5½ feet. It consists dominantly of quartz which is somewhat sparsely mineralized with arsenopyrite and pyrite. An average sample was taken across the vein from the end of the crosscut, which was assayed and found to contain:

Gold		Silver		Total value per ton gold and silver
Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
0·34	$6.80	0·66	$0.33	$7.13

On the Victoria claim an underground crosscut has been driven into the hill a distance of 140 feet, which encountered two veins at distances of 85 and 100 feet respectively. The first is called the Victoria vein, and the second will here for convenience be designated the No. 2 vein. On the Victoria vein a drift has been run to the right of the crosscut 27 feet, and to the left 30 feet. This vein strikes practically due east, and has an almost vertical attitude; it consists mainly of quartz which is well mineralized with arsenopyrite and some pyrite, and is heavily stained with a greenish arsenate of iron. In the right drift, this vein is particularly well mineralized, is porous and somewhat decomposed, and has a thickness of 12 to 18 inches. An average sample taken across the vein in the face of this right drift, where it is 18 inches thick, was assayed and found to contain:

Gold		Silver		Total value per ton gold and silver
Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
0·69	$13.80	1·01	$0.55	$14.35

In the left drift this vein gradually becomes thinner until at the end of the 30 feet it is only 1 inch to 4 inches thick. It is near this point joined by

No. 2 vein which is there over 4 feet in thickness, strikes south 43 degrees west (astronomic), and has an almost vertical attitude. No. 2 vein although thick in places is not, where exposed, as well mineralized as the Victoria vein, and where encountered in the main crosscut is irregular and mainly represented by a fracture zone including only 2 to 6 inches of quartz. These veins both occur in fissures in the typical schistose rocks of the vicinity, and like all other veins in this formation, are rather irregular in form. An average sample was taken at the end of the left drift, at the junction of No. 2 and Victoria veins, where the quartz is $4\frac{1}{2}$ feet in width, but is only sparsely mineralized. This sample was assayed and found to contain:

Gold		Silver		Total value per ton gold and silver
Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
0·10	$2.00	0·15	$0.07	$2.07

The green vein is exposed in the left bank of Olive gulch opposite the Olive workings. A very considerable amount of development has been performed on this vein, including about 290 feet of underground work, as well as numerous open-cuts, trenches, and other surface openings. The underground work includes a crosscut or adit 60 feet long, which really drifts on the vein for about 50 feet. At the end of this crosscut, a drift is continued along the general strike of the vein for 130 feet, and from the end of this drift there is a 27-foot upraise. Also from the main drift two smaller drifts or crosscuts have been driven distances respectively of 40 and 30 feet. The vein was first encountered in these underground workings about 10 feet from the surface, and is there in the granitic intrusives. About 40 feet farther, however, it passes into the schistose rocks, and throughout the rest of the workings, remains in this formation. The vein in a general way strikes almost due east and west, the same as the Victoria vein, and like it, has an almost vertical attitude. It ranges in thickness from 10 to 36 inches, but is in most places 12 to 20 inches thick. It is also generally well mineralized, but is rather irregular in form and mineralization. The vein is joined by numerous stringers and veinlets, and in places consists for the greater part of fractured bunches or masses of quartz and sheared and somewhat mineralized wall rock, distributed along the general fault zones. Four samples were taken from these underground workings. No. 1 is an average across the vein where 2 feet thick, and where well mineralized, near the top of the upraise. No. 2 is an average across the vein where exposed in the end of the main drift, where the vein is 14 inches thick and well mineralized. No. 3 is an average across the vein in the breast of one of the small drifts where it is 12 inches thick and not well mineralized. No. 4 is an average across the vein zone near the beginning of the main drift. The fracture zone here is 24 inches wide, but is almost barren of apparent mineralization. These samples were assayed and found to contain:

Sample No.	Gold		Silver		Total value per ton gold and silver
	Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
1	0·40	$ 8.00	0·52	$0.26	$ 8.26
2	0·56	11.20	1·09	0.54	11.74
3	0·10	2.00	0·50	0.25	2.25
4	Trace	......	Trace	.....	.....

The *Blue Lead* and *Eagle groups* adjoin one another and consist each of eight unsurveyed claims which are owned by Messrs. Robert Fisher, B. C. Spragg, A. Aimes, and others, and were staked about the year 1910. The claims extend along the left side of Dublin gulch from Stewart gulch to near the valley of Haggart creek, there being, however, a group of four undeveloped claims owned by John Maynard, between the Eagle group and Haggart creek. Quite a number of veins have been discovered on these groups, which range from stringers about an inch thick to veins said to be 2 to 3 feet thick. All occur in fissures which are partly in the granitic intrusives and partly in the schistose rocks of the vicinity. The veins are very similar in character, and consist mainly of a quartz gangue which includes varying amounts of arsenopyrite with also some pyrite, and all the better mineralized deposits are stained with a greenish arsenate of iron. A considerable amount of prospecting development work has been performed on these claims, including numerous trenches, pits, and open-cuts, three adits, 38, 120, and 35 feet long, and a 35-foot shaft. The works were nearly all more or less caved in when visited, so that none of the more important veins was exposed. A considerable number of stringers 1 inch to 4 inches thick were seen, however. At one point on top of a narrow ridge a vein occurs which is said to be 2½ feet thick, and on which the 35-foot shaft is sunk. Around the top of the shaft were a number of fairly well mineralized pieces of vein material representing vein sections 6 to 10 inches in thickness. A fairly average sample of these larger pieces was taken. This was assayed and found to contain:

Gold		Silver		Total value per ton gold and silver
Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
0·10	$2.00	0·95	$0.47	$2.47

Other Localities

Important discoveries of other mineral veins have been reported from a number of points in Mayo area. A rich silver-lead vein was recently found not far to the south of the lower end of McQuesten lake. Quartz veins claimed to contain important amounts of gold and silver occur on Christal and Lightning creeks. A number of veins are reported to occur on Mt. Haldane, and on Duncan creek at least two important veins are exposed along the right bank of the stream a short distance above the forks. The lower of the two, outcrops on Discovery placer claim just below the canyon, and about 40 feet above the creek level. It is apparently 3 or 4 feet thick, but is claimed by men who have stripped it to be 5 feet in thickness. When visited it was very poorly exposed, and its thickness, dip, and strike were thus largely obscured. The vein consists mainly of sphalerite (zinc blende) with some chalcopyrite and pyrite, and subordinate amounts of quartz and calcite. An average sample was taken across the exposure and was assayed for gold and silver, but owing to an error was not assayed for zinc, its most important constituent. The gold and silver content is as follows:

Gold		Silver		Total value per ton gold and silver
Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
0·08	$1.60	7·12	$3.56	$5.16

The other vein occurs higher up in the canyon and is similar in general appearance, but appears to be narrower than the one just described. It was, however, poorly exposed, and was so weathered and oxidized on the surface, due to a spring of water in the vicinity, that no satisfactory sample could be at all readily obtained.

Summary and Conclusion

The stream gravels of a number of the creeks within Mayo area have been found to carry considerable amounts of placer gold, and the available evidence would indicate that the gravels along numerous other streams within the district will also be found to be gold-bearing to an important extent. The recent discovery of coarse gold on Johnson creek is an example of what will yet probably happen in many other places when the creeks of the district are more thoroughly prospected, as the geological conditions are very similar throughout the district. In most places, only the present stream gravels have as yet been worked, and it seems probable that the amount of gold still contained in the deep and bench gravels is as great or greater than that in present creek deposits. The placer gold yet to be derived from this area will thus probably amount to much more—possibly many times more—than that already recovered.

Valuable lode deposits as yet unknown will undoubtedly also be discovered throughout Mayo area, but until transportation facilities are greatly improved, they will constitute for some time mainly a future asset to the district, except where they are very rich as is the Galena Creek ore.

SCROGGIE, BARKER, THISTLE, AND KIRKMAN CREEKS, YUKON TERRITORY

by D. D. Cairnes

After completing the geological work for the season in Duncan Creek mining district, described in previous pages, about ten days were spent in investigating the gold-bearing gravels, and placer mining possibilities on Scroggie, Barker, Thistle, and Kirkman creeks. These streams all head near one another in the divide between Stewart and Yukon rivers, to the south of the Stewart; but in their courses they radiate out from the central area in which they have their source, and flow in northerly, westerly, and southerly directions—Scroggie and Barker to join the Stewart, and Thistle and Kirkman to Yukon river.

These creeks were all discovered* and staked in 1898 and since then placer mining has been in progress on them, with the result that between $200,000 and $300,000 in gold has been produced. Very little authentic information, however, was available concerning the geological conditions and mining possibilities along these creeks or throughout the district in which they occur. Practically the only published information available was that contained in a report by R. G. McConnell who visited Thistle creek in 1901 and briefly described the conditions prevailing there**; at that time, however, very little mining had been done.

These creeks all occur within the older schistose belt, the rocks exposed being dominantly schists, gneisses, and limestones of possibly Pre-Cambrian age, similar to those so extensively developed in the Klondike and other prominent placer mining camps in Yukon and Alaska. The locality lies outside the glaciated zone, which is greatly in its favour as a placer gold district, since whatever gold has been concentrated in the stream gravels remains practically undisturbed, except where it has been reconcentrated by more recent stream action; and, furthermore, the gold-bearing gravels are not overlain by vast accumulations of glacial detritus, as is the case in many glaciated localities.

Prominent, wide terraces or benches extend along these creeks, the bedrock of which is overlain by stream gravels which on Barker and Thistle creeks have proved to be important sources of placer gold. The bench gravels are almost entirely unprospected not only along Scroggie and Kirkman creeks, but also along the greater part of Barker and Thistle creeks. The benches, along each stream, represent a former, higher position of the creek, and should consequently be carefully prospected, as it is probable that the gravels on the benches are as important as those on the creek bottoms or more so, especially in places where the benches have not been destroyed by the creeks in sinking their lower more recent channels. A brief description of the four creeks follows and a detailed report is in preparation.

Scroggie Creek

Scroggie creek flows in a westerly to northwesterly direction, and joins Stewart river about 25 miles above its confluence with the Yukon. When visited during the past summer, about twenty men were engaged in placer mining along the stream and its tributary Mariposa creek, and during the winter months in recent years, an average of from forty to fifty men are reported to have been there employed. Mining operations have been entirely confined to the gravels in the creek bottom, which have been worked by both underground drifting and open-cut methods. In most places, the mining has

* In Yukon when gold is found on a creek and a 'Discovery' claim is staked, the creek is said to be 'discovered'.

** McConnell, R. G., "Thistle Creek": Geol. Surv., Canada, Ann. Rept., Vol. XIV, 1901, pp. 31A, 32A.

been performed by drifting, and as this method can be pursued during the winter months, a greater number of men work on this creek in winter than in summer when many other kinds of work are available, and when other forms of placer mining and prospecting can be conducted to best advantage. The total amount of gold that has been produced from Scroggie creek and its tributaries is generally estimated to be between $50,000 and $75,000, but some claim it to be between $75,000 and $100,000.

Barker Creek

Barker creek has a general northerly course, and joins Stewart river about 2 miles below the mouth of Scroggie creek or 23 miles above the mouth of the Stewart. When visited during the past summer (1915) only seven men were living on Barker creek, who were engaged in mining, but of these one man was holding, for mining purposes, about 5 miles of the creek, commencing 8 miles above the mouth. Both the bench and creek gravels along this stream have been worked to a limited extent; the bench gravels, however, have proved up to the present to be the more remunerative, and the development to date would warrant their thorough investigation, and would indicate that they are likely to prove of considerable importance. The creek gravels have been worked mainly by underground drifting, and the bench deposits by the hydraulic method. It is estimated that between $25,000 and $30,000 in gold has been obtained from this creek.

Thistle Creek

Thistle creek follows a general westerly course, and joins the Yukon about 20 miles above the mouth of Stewart river. Thirteen men were engaged in placer mining on this creek when it was visited, but a few who spend most of their time there, had gone over to Kirkman creek temporarily. The mining operations along Thistle creek have been restricted mainly to the bench gravels which are hydraulicked during the summer months. The creek gravels have also been worked to a limited extent, mainly by drifting, and are still so mined, especially during the winter months, when hydraulic and open-cut methods are impossible. In all, it is believed that about $125,000 in gold has been produced from this creek which has thus been the most productive of the four creeks considered in this report.

Kirkman Creek

Kirkman creek flows in a general southerly direction, and joins Yukon river 8 miles above the mouth of Thistle creek, or 28 miles above the confluence of the Stewart and Yukon. Although Kirkman creek was discovered in 1898, and has been prospected at different times since, no actual mining took place until after April, 1914, when J. C. Britton and William Haas made a discovery which caused a stampede to the creek. During the following winter (1914-15), an average of about forty men were engaged in mining along this stream, and throughout the ensuing summer about thirty men were employed. More men engage in mining along these creeks in winter than in summer, owing to the fact that the creek gravels along these streams can be worked by the drifting method which may be pursued to advantage during the winter, when very little other work is available in Yukon, and when prospecting and practically all other forms of placer mining are impossible. Between the date of discovery in April, 1914 and October, 1915, it is estimated that about $8,000 in gold was produced from Kirkman creek, the mining operations being mainly confined to two miles of the creek commencing about 5 miles above the mouth, or just above a portion of the creek channel that is somewhat constricted, and is locally spoken of as the 'canyon'.

WHEATON DISTRICT, SOUTHERN YUKON*

by D. D. Cairnes

The early part of the past season (1915) was spent in Wheaton district, southern Yukon. During the summer of 1909, the writer made a phototopographic survey of this area, and at the same time made a geological examination of the district. The geological mapping was, however, necessarily of only a preliminary nature, owing to the fact that at the time no topographic map was available upon which to plot the various geological formations, and all geological outcrops, contacts, etc., had to be recorded in note form only, which is at best very unsatisfactory. The topographic work performed by the writer in 1909 was compiled by the topographic division of this Department, and advance sheets suitable for field work became available last spring, affording thus an opportunity to revise the previous geological mapping in a satisfactory manner, using this map as a topographic base. Another important reason for performing geological work in Wheaton district at this time, was that a number of important deposits of antimony minerals were known to occur within the area, which have been more or less developed since 1909, and since the war there has been an increased demand for antimony and its price has advanced greatly. The writer accordingly received instructions to revise the geological mapping of Wheaton district, and to make an examination of the mineral deposits occurring within its boundaries, particular attention to be paid to those containing antimony minerals.

The topographic map upon which the geology was plotted is published to a scale of $\frac{1}{62,500}$, or approximately one mile to the inch, and every care was taken to have the geological mapping performed so as to be consistent with this scale.

The writer was ably assisted in this work by William Cockfield.

Location and Area

Wheaton district is situated in the southern portion of Yukon Territory, its southern edge being from 12 to 15 miles north of the 60th parallel of latitude (the British Columbia-Yukon boundary). The area included is approximately 20 miles long in an east and west direction, and 15 miles wide from north to south. The district is flanked on the west by the eastern slopes of the mountains of the Coast range, and extends thence eastwards to longitude 135° 53′, or to within a distance, as the crow flies, of 6 miles from the White Pass and Yukon railway. Wheaton river which has given its name to the area, flows, throughout the lower portion of its course, in a

*For further information concerning the geology, mineral resources, topography, and other features of Wheaton district, the reader is referred to the following more detailed report: Cairnes, D. D., "Wheaton district, Yukon Territory"; Geol. Surv., Canada, Memoir No. 31, 1912.

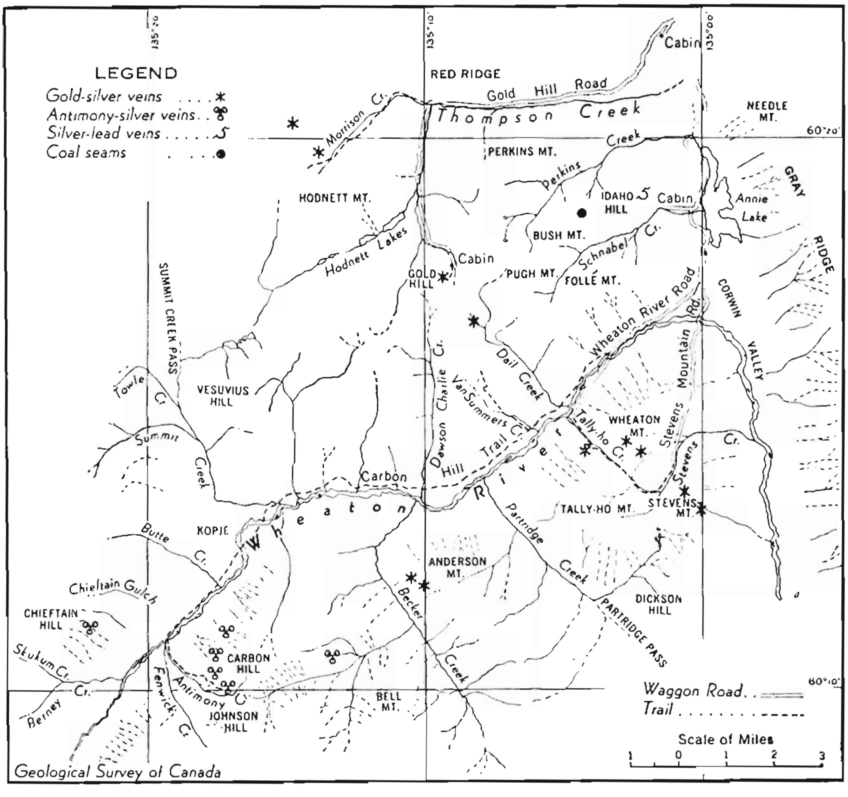

Figure 3. Wheaton district.

general direction almost due south, and empties into Lake Bennett; 12 miles above its mouth, however, the river turns abruptly to the west forming what is known as the 'Big Bend' of the Wheaton, and throughout the portion of its course from the Big Bend to near its headwaters, the stream flows in a general easterly to northeasterly direction. Wheaton district, as the term is here used, includes only the particular area mapped in 1909; this area extends along both sides of Wheaton river from above 6 miles below the Big Bend, to about 18 miles above it.

Means of Communication

Wagon roads have been constructed by the Yukon government, from Robinson on the White Pass and Yukon railway, to various parts of the district. One road extends along Wheaton river to Carbon hill which is situated in the most westerly portion of the area, about 30 miles distant from Robinson; and a branch from this main road has been built to Stevens camp near the summit of Mt. Stevens. Another road 20 miles long, has been constructed from Robinson to Gold hill which lies 3 to 4 miles north of Wheaton river, and midway between that stream and Watson river. All parts of the district are thus easily accessible, and only short, easily constructed branch roads are necessary to connect all the mineral properties, not already so connected, with the railway.

Robinson is distant 78 miles, by rail, from Skagway, Alaska, whence several lines of well equipped steamships sail regularly to Vancouver and Seattle, distances, respectively, of 867 and 1,000 miles.

Topography

Topographically, Wheaton district occupies a position along the extreme western edge of the Yukon Plateau physiographic terrane, and is thus bordered on the west by the mountains of the Coast range. There is here, however, no very marked distinction between the land features of these two topographic provinces along their boundary; in fact, in most places, it is difficult to decide just where the dividing line should be placed.

Within Wheaton district, possibly the most striking point in connection with the topography is the marked contrast between valleys and upland, both of which possess very pronounced characteristics. The valleys are typically deep, steep-sided depressions the walls of which rise abruptly 2,000 to 3,000 feet to the upland above. Between these incision-like valleys, high gently rolling stretches of an upland surface occur, there being everywhere an abrupt change representing a topographic unconformity at the junction of the upland with the tops of the valley walls. This upland constitutes part of an old plateau which possessed only slight relief and extended, practically unbroken, from the mountains of the Coastal system on the west, eastward to the Rocky mountains, a distance of from 250 to 300 miles. Even yet, to an observer standing on this upland surface, well back from the edge of a valley wall, so vast an expanse of gently rolling surface presents itself to his view, that it is easy to imagine the intersecting valleys again refilled or to forget that they have ever been excavated; and thus a picture of the landscape as it existed before the valleys were incised, is presented.

This plateau is generally conceded to represent a maturely eroded surface, that was reduced by ordinary normal erosion processes to a nearly plain-like condition, during a long period throughout which this portion of the earth's crust remained relatively stable. The erosion interval was interrupted, however, in what is thought to be late Tertiary time by a regional uplift which in Wheaton district amounted to about 3,600 feet, and as a result of this crustal movement a lowland tract became a highland surface. The uplift gave renewed life and energy to the streams which were thus soon able to cut deep, V-shaped incisions into the new upland, and these now constitute the main valleys of the district. At a later period glacial ice invaded Wheaton district, and occupied all the main depressions which as a result of ice action, became both widened and deepened, and gradually assumed pronounced U-shaped cross-sections. Also, such well known glacial forms as cirques, hanging valleys, *roches moutonnées*, and kettle-holed valley floors were produced. The morainal and other materials which were deposited in the valley bottoms, blocked the stream courses in different places to such an extent that even yet the drainage is very imperfect, and lakes or ponds, many of them surrounded by muskeg or tundra, now occupy important depressions, through which large and important streams once flowed.

Since the retreat of the ice, V-shaped incisions have been etched in the valley walls, and at the margins of the upland surface, resulting in the production between them of pronounced facetted forms. The main streams have also sunk their channels to some extent in the unevenly distributed deposits strewn over the valley floors, so that occasional sand, gravel, silt, or boulder-clay banks, 200 feet or more in height, have been produced. Disregarding these relatively slight changes, however, the topography of Wheaton district is as the ice left it, and the forms or features which were produced by glaciation still exist in a marked state of preservation.

General Geology

Wheaton district is situated, as before mentioned, along the eastern edge of the Coast range, and practically the entire area is believed to be underlain by the granitic rocks of the great Coast Range batholith; which outcrop throughout by far the greater part of the area. A study of the geology of Wheaton district thus involves throughout, that of this important granitic terrane. In addition to the granitic intrusives, however, which are of Cretaceous or Jurassic age, numerous other rock types occur, including igneous, sedimentary, and metamorphic varieties which range in age from possibly Pre-Cambrian to Recent.

In the eastern portion of Wheaton district, the present upland surface very nearly coincides with the original top of the Coast Range batholith, so that there, numerous remnants of the former roof of this igneous mass are still preserved. The older rocks also constitute walls separating subjacent portions of this vast granitic body; in addition, numerous small isolated masses of the older invaded formations remain, which are distinctly seen to be inclusions in the granitic intrusive, occurring as they do throughout it at various elevations. Toward the west, nearer the centre of the batholith, the older rocks gradually disappear, as the central portion which was originally the highest has been more deeply eroded than the rest and, as a result, the overlying and included older rocks, all of which were originally mainly at or relatively near the surface of the batholith, have been to a great extent removed.

Throughout Wheaton district the geology is complicated and intricate, due in part to the great diversity in age and character of the various formations that occur, but more particularly to the fact that the area has been subjected to a number of intense volcanic invasions. As a result of each invasion the older rocks have been cut, pierced, and in some cases buried by the invading volcanics, and so each successive period of volcanic activity added to the geological complexity of the region.

*Table of Formations**

Era	Period	Formation	Lithological character
Quaternary		Superficial deposits	Gravel, sand, clay, silt, soil, muck, volcanic ash, ground-ice, slide rock and morainal materials.
Tertiary	Probably mainly about Pliocene, but may include older members, and may also continue up into the Pleistocene		Rhyolite, granite-porphyry, and related volcanics, with their associated tuffs and breccias. Some granitic types also occur.
			Andesite, basalt, and related dyke rocks and other volcanics, with their associated tuffs and breccias.
Mesozoic	Cretaceous to Jurassic	Coast Range intrusives	Granitic rocks ranging in composition from granite to diorite, with associated porphyritic phases.
	Probably Lower Cretaceous		Andesite, diabase, basalt, and related volcanics, with associated tuffs and breccias.
	Lower Cretaceous or Jurassic	Laberge series	Argillite, metargillite, shale, sandstone, arkose, greywacke, conglomerate, and breccia.
	Jurassic	Probably corresponds to the Kootenay	Conglomerate with sandstone, shale, and seams of coal.
Palæozoic	Carboniferous(?)		Limestone, more or less dolomitic.
	Devonian(?)		Pyroxenite mainly; probably peridotite and related rocks also occur.
Pre-Cambrian(?)		Mt. Stevens group	Chiefly sericitic and chloritic schists, mashed basic to semi-basic volcanics, gneissoid quartzite, hornblende gneiss, and limestone.

* The rocks of Wheaton district have been here somewhat differently subdivided and classed than in the writer's previous work to which reference has been made. This change has been found advisable after a number of years further geological study in Yukon—one of the chief reasons for the rearrangement being that by grouping the rock terranes as here shown, they may be much more readily correlated with the rock formations now known to occur elsewhere in Yukon as well as in northern British Columbia and Alaska.

Summary Description of Formations

The oldest rocks known to occur in Wheaton district are included in the Mt. Stevens group, and are chiefly sericite and chlorite schists, mashed basic volcanics, gneissoid quartzites, hornblende-gneisses, and limestones.

These occur in a number of localities, but in most places constitute only small isolated outcrops representing remnants of the roof of the Coast Range batholith, or inclusions in that igneous mass. In the eastern part of the district, however, one particularly extensive development of these rocks occurs, constituting a long, deep wall dividing subjacent portions of the granitic batholith; this wall has been cut by Wheaton river to a depth of nearly 3,000 feet, and it appears to persist to still greater depth. All the members of the Mt. Stevens group suffered prolonged dynamic metamorphism, were much disturbed, broken, contorted, and plicated, and were afterwards subjected to long periods of erosion, concerning which relatively little is known. They are thought to be, in all probability, of Pre-Cambrian age.

More recent than the members of the Mt. Stevens group are certain pyroxenites with which are probably associated peridotites and related rocks. Outcrops of the pyroxenites were seen only in one small area situated on the southern portion of Tally-Ho mountain, and at this point they cut the members of the Mt. Stevens group. No other definite information was obtained in the district concerning the age of these rocks, but from their lithological similarity to rocks in other portions of Yukon and in northern British Columbia, they are thought to be probably of about Devonian age. In the writer's former report on this district, these rocks were included in the Perkins group, a name the use of which it is now considered advisable to discontinue.

At a few points, mainly along the west face of Needle mountain, and on Idaho hill, small isolated masses of limestone occur, which rarely exceed 100 feet in thickness, and are merely detached blocks that have been carried upward by igneous masses mainly by the Mesozoic andesitic rocks or by the Coast Range intrusives. On the south face of Mt. Bush a fairly persistent bed of limestone, apparently about 6 feet in thickness, also occurs underlying the coal-bearing conglomerates. The isolated limestone masses, as well possibly as the bed on Mt. Bush, are thought to be probably of Carboniferous age. None of this limestone, however, is of any particular areal importance.

In Mesozoic times a considerable thickness of arenaceous and argillaceous sediments was deposited in this portion of Yukon. In Wheaton district these have been for the greater part removed by erosion, but in the northeast corner of the area they are in part still preserved, and have there an aggregate thickness of 5,000 to 6,000 feet. These sediments are divisible into two groups or formations—the Laberge series, and a conglomerate series which appears to correspond to the Kootenay. The Laberge beds consist mainly of argillites, metargillites, shales, and sandstones, with also some arkoses, greywackes, conglomerates, and breccias. A few indefinite or poorly preserved invertebrate fossil remains have been found in these beds, which have been considered to be of either Lower Cretaceous or Jurassic age. The conglomerate series which in places has a total thickness exceeding 1,000 feet, appears to underlie the Laberge beds, but of this no absolute proof could be obtained, owing to the greatly disturbed condition of these sediments. The conglomerate formation consists prevailingly of a fine to medium textured, dark, cherty conglomerate, with also some sandstones, shales, and seams of coal. Fossil plants were collected from these beds during the past summer, which have been determined by Dr. F. H. Knowlton of the United States Geological Survey, to be of Jurassic age. Dr. Knowlton also states that some of the species have been found in the Kootenay or at least have been reported from that formation. Since, therefore, these beds contain coal seams, and are lithologically very similar to the Kootenay members farther south, they would seem in all probability, to belong to that formation.

More recent than these sediments, there occurs an important group of volcanic rocks including mainly andesites, diabases, basalts, and related volcanics, with their associated tuffs and breccias, which have extensively invaded the older rocks of the district. This volcanic group appears to represent the same period of volcanic activity as the 'Older Volcanics'* of Upper White River district, and other portions of Yukon and Alaska.

These volcanics are in turn cut by the Coast Range intrusives, which constitute much the most important and most extensively developed geological terrane in the district. These intrusives range in composition from granite to diorite or may be even more basic in character; they appear to be dominantly, however, of about the composition of granodiorite, and have everywhere a pronounced granitic habit. These rocks were first thought to be all of Jurassic age, and when working in Wheaton district in 1909, boulders of these intrusives were found in the lower conglomerate beds of the Laberge series. The intrusives were considered, therefore, to antedate these sediments in age. Since that time, further work in other portions of Yukon as well as in northern British Columbia, where contacts between the Coast Range intrusives and the members of the Laberge series are better exposed, has shown that the intrusives also cut the Mesozoic beds, and are partly older and partly younger than these sediments**. In fact recent studies of the Coast Range batholith in different districts, have shown that this terrane represents several intrusive periods ranging from some time in the Jurassic to well into Cretaceous time. This has given rise to considerable difficulty and complexity in connexion with geological work in the vicinity of the Coast Range batholith. In Wheaton district, it is now known that these rocks are dominantly at least or perhaps entirely, more recent than the Mesozoic sediments, and are probably all of Cretaceous age. In the writer's former work in this district, certain andesitic and related volcanics were known to be older than the Coast Range intrusives, and were consequently believed to be older than the Mesozoic sediments, and were included in the Perkins group. Other similar andesites and related volcanics were known to be more recent than the Laberge members and were grouped separately under the name Chieftain Hill volcanics. All these andesitic and related volcanics are now regarded as belonging to the same formation, as just described, and as shown in the above table of formations.

Cutting the Coast Range intrusives, there occurs an important group of volcanic rocks comprising mainly andesites, basalts, and related volcanics, including various types of dyke rocks, with their associated tuffs and breccias. These rocks are quite extensively developed in the extreme western portion of the district, and are everywhere quite recent in appearance—lava flows in which the flow structure is still very marked, and beds of tuff and ashes, constituting probably the most prominent members. These rocks

*Cairnes, D. D., "Upper White River district, Yukon": Geol. Surv., Canada, Memoir 50, 1915, pp. 87-93.

**Cairnes, D. D., "Atlin Mining district, British Columbia": Geol. Surv., Canada, Memoir No. 37, 1913, p. 59.

correspond to the 'Newer Volcanics' of Upper White River district*, and other portions of Yukon, and include the Carmack basalts. They are considered to be of Tertiary and probably of late Tertiary age.

Another important group of volcanic rocks, includes mainly rhyolites, granite-porphyries, and related rocks, which are the most recent consolidated rocks of the district, and are of late Tertiary or possibly even in part of early Pleistocene age. These volcanics do not generally cover any very large individual areas, but occur rather as dykes and similar intrusive bodies. Innumerable dykes occur cutting the Coast Range intrusives and other older rocks, and in certain localities so extensive has been the invasion of these volcanics that they appear to be almost as prominent as the invaded formations. In places these volcanics have quite a marked granitic habit, and might locally be termed porphyritic granites or, possibly, granites. In the writer's previous work on Wheaton district, these rocks were divided into two groups: one including the rhyolitic members which were termed the Wheaton River volcanics, and the other the granite-porphyries, which were named the Klusha intrusives. This subdivision has since been found to be somewhat impracticable, particularly in adjoining districts where every transition occurs between these two lithological phases of apparently the same rock magma.

Overlying all the consolidated rock formations of the district are the Pleistocene and Recent accumulations which include mainly gravels, sands, clays, silts, soils, muck, volcanic ash, ground-ice, slide rock, and morainal materials. These accumulations not only deeply cover all the main valley bottoms of the district, but in addition extend over considerable portions of the upland as well as of the valley walls.

Mineral Resources

The mineral resources of Wheaton district embrace, mainly, ore deposits of different kinds, but also include coal. The ore deposits are of four principal types, viz:

(a) Gold-silver veins.
(b) Antimony-silver veins.
(c) Silver-lead veins.
(d) Contact-metamorphic deposits.

Of these varieties the gold-silver and the antimony-silver veins are of the most importance. The silver-lead veins are quite limited in extent, and the contact-metamorphic deposits, so far discovered, are too low grade, and are insufficient in size to be of any present economic importance. Coal has been found only in one locality, on Mt. Bush, and has been only slightly prospected. All these mineral deposits are described in the writer's report** on Wheaton district, and in most cases will not require to be more than briefly mentioned. Detailed descriptions are given of the antimony deposits, and of certain of the other deposits on which important development work has been performed since the previous examination in 1909.

Gold-Silver Veins

Veins of the gold-silver variety constitute the most widely distributed type of ore-deposit found in Wheaton district. The more important of these

*Cairnes, D. D., "Upper White River district, Yukon": Geol. Surv., Canada, Memoir 50, 1915, pp. 97-101.

**Cairnes, D. D., "Wheaton district, Yukon Territory": Geol. Surv., Canada, Memoir No. 31, 1912, pp. 85-146.

veins that have been so far discovered, occur on Mt. Anderson, Mt. Stevens, Wheaton mountain, Gold hill, and along the south side of Watson river to the north of Hodnett mountain. On the various deposits occurring on Gold hill, Hodnett mountain, and to the north of Hodnett mountain along the south side of Watson river, no development work has been performed, except possibly a slight amount of representation work, since they were visited by the writer in 1909[1]. On the south side of Gold hill, near the head of Dail creek, a vein occurs which is typical of the veins in this locality, and has not been before described. This vein occurs in a fissure in the Coast Range granitic rocks, strikes about 8 degrees south of east[2], and dips at angles of from 75 to 85 degrees to the south; and where exposed in Dail creek has a width of from 8 to 20 inches, and is at an elevation of about 4,800 feet above sea-level, or 2,100 feet above the mouth of Dail creek. The vein consists mainly of white quartz which is somewhat iron-stained, and in most places contains disseminated galena, and occasional particles of a black telluride which appears to be sylvanite. Three samples were taken from the vein. Nos. 1 and 2 are averages across the vein where it has thicknesses of 14 and 20 inches respectively. No. 3 is an average of a number of particularly well mineralized specimens. These samples upon being assayed, were found to contain[3]:

Sample No.	Gold		Silver		Total value per ton gold and silver
	Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
1	0·25	$5.00	0·75	$0.37	$5.37
2	0·11	2.20	1·99	0.99	3.19
3	1·51	30.20	15·74	7.87	38.07

On Mt. Stevens as well as on Wheaton mountain, a number of claims are still held, but practically no development work has been performed since 1909, except the relatively small amount required by law to hold the properties, and several claims have been crown granted. On the Buffalo Hump group[4] on Mt. Stevens, several tons of rich quartz were at one time discovered, which contained galena, native gold, and sylvanite. This quartz was at first thought by the owners to be in place, but subsequent development work showed it to be transported. Since this quartz occurred in such quantity near the summit of the mountain, and showed no evidence of having been moved any considerable distance, it would seem most probable that it would be found in place somewhere on Mt. Stevens. Other smaller pieces of rich quartz have also been discovered at other points on the mountain. An adit was driven 90 feet into the hill underneath the rich quartz, and some 30 feet of crosscuts or drifts were driven from the adit, in the hope of finding the vein from which the gold-telluride quartz was

[1] Op. cit., pp. 111-113.

[2] All bearings given in this report unless otherwise mentioned are astronomic or true. The magnetic declination throughout the district averages about 32° 30′ east.

[3] All the assays quoted in this report were made at the Government assay office at Whitehorse.

[4] Op. cit., p. 107.

derived; but, apparently, no more of the rich ore was encountered. It has been claimed though, that a galena-bearing vein was crosscut by the adit; on each occasion when this property was visited by the writer, however, the adit was filled with ice and could not be examined. In addition to this work and a 20-foot shaft on the McDonald fraction on Wheaton mountain, the only development work that has been performed on Mt. Stevens and Wheaton mountain consists of a number of open-cuts, trenches, and shallow pits. All the veins that have been discovered seem to carry very low average values. Possibly the most promising vein on Wheaton mountain is that exposed on the McDonald fraction[1]. This vein was fairly well exposed in an open-cut and several average samples were taken from it. Approximate average samples were also taken from the dump at the 20-foot shaft on this claim. These samples all assayed less than $1 per ton in combined gold and silver.

The thickest, most persistent, and apparently the best mineralized vein exposed on the Buffalo Hump group, occurs on the Sunrise claim. This vein occurs in a fissure in the Coast Range granitic rocks, strikes south 45 degrees east, and dips at angles of 20 degrees to 35 degrees to the north-east. It is composed dominantly of quartz which contains occasional disseminated particles of galena and pyrite. Several average samples from this deposit where it is exposed at the surface, were assayed, and found to contain less than $1 per ton in combined gold and silver. High assay values have undoubtedly been at times obtained from the veins of this locality, but the values are very erratically distributed. The rich float, also, has been derived, in all probability, from high grade pockets in veins similar to those already found; in fact, it is more than probable that it came from some of the veins already known to occur on Mt. Stevens.

On the Tally-Ho group[2] on Tally-Ho mountain, an important vein occurs on which considerable underground development work has been done though practically only representation work has been performed since it was last examined.

On Mt. Anderson, on the east side of Becker creek, a number of claims are owned by Becker and Cochran, on which an important amount of development work has been recently performed—this being really the only vicinity in which there have been any important mining operations in connexion with veins of the gold-silver type, since the district was formerly examined.

Becker-Cochran Property

A number of mineral claims owned by Theodore Becker and Howard Cochran have been located on the west face of Mt. Anderson, about 2 miles south of Wheaton river, measured as the crow flies. These claims comprise the Whirlwind and Mountain Sheep groups which adjoin one another, and consist of 6 and 5 claims respectively, including the old 'Rip' and 'Wolf' claims[3]. What appear to be two main veins, and one or more others of less importance, have been discovered on these claims, all of which occur in fissures in the Coast Range granitic intrusives. The veins extend along the face of Mt. Anderson for a distance of 2,000 feet or more, and outcrop at elevations of from 4,600 to about 5,050 feet above sea-level, the elevation

[1] Op. cit., p. 108.
[2] Op. cit., pp. 108-110.
[3] Op. cit., pp. 110-111.

of Wheaton river at the mouth of Becker creek, being slightly over 2,800 feet above the level of the sea. The greater part of the development has been performed on the Whirlwind group on what is termed the 'lower vein' which strikes about north 68 degrees west and dips to the northeast at angles ranging from 80 degrees to nearly vertical. The vein consists chiefly of quartz which is mineralized with argentiferous galena. A striking feature in connexion with this vein is that it has been invaded by a basalt dyke about 2 feet in thickness, which persistently accompanies it throughout its entire length as far as explored. This dyke in places occurs along the hanging-wall, and at other points follows along the foot-wall, but generally occupies an intermediate position within the vein; in places also the dyke branches into two or more portions all of which may be included within the quartz. A drift known locally as 'No. 2 tunnel', has been driven in on this vein about 350 feet, throughout which distance the quartz has a thickness in most places of from about 8 inches to 4 feet, and maintains a general average exceeding 18 inches. At the entrance to the drift, the quartz has a total thickness of 6 feet, the basalt dyke occurring within 12 inches of the hanging-wall. About 150 feet below this drift, a crosscut 172 feet long has been driven to the vein and a drift from the end of the crosscut follows the vein for about 150 feet. The crosscut and drift together are generally termed by the owners 'No. 1' or 'the lower tunnel'. Throughout this lower drift, the quartz has a thickness of from 6 inches to 4 feet with an average of perhaps 18 to 20 inches.

Continuing to the southeast along the face of Mt. Anderson, vein outcrops have been exposed by a number of pits, small open-cuts, or trenches, for a distance of, possibly, 2,000 feet. These vein outcrops show the same characteristics as the lower vein just described, and are persistently accompanied by the same basalt dyke or by a very similar one. They may be portions of two or possibly three additional veins, or may be a southeasterly extension of the lower vein, that has been successively offset in an easterly direction, farther and farther into the mountain by transverse faulting. A surveyed plan of all vein outcrops gives support to this theory, showing as it does three fairly definite and distinct lines of outcrops, all with similar strikes, but swinging successively more to the east as the south is approached, and each line of outcrops commencing practically opposite the last outcrop of the next line of exposures. On the Mountain Sheep group, in the most southeasterly of the three lines of outcrops, there occurs an important exposure, designated by the owners, the 'big showing'. There the basalt dyke is somewhat complex or irregular in form, but the quartz has an aggregate thickness of from 3½ to 4½ feet, and is well mineralized. About 100 feet past this showing, an adit or crosscut was driven into the hill during the winter of 1914-15, in a direction at right angles to the general strike of the vein at the 'big showing', but no evidence of the vein was encountered, although the adit was driven some distance past the point where it would have been crosscut had it continued this far in regular fashion. Since the vein had persisted so far, and was strong and well defined within 100 feet of this crosscut, it would appear most probable that it has been further offset by a fault similar to those already indicated. All the available evidence is, therefore, in favour of the fault theory, though its truth can be established only by further development.

The lower vein in the lower drift has been carefully sampled throughout by the owners, and is claimed by them to average $10.60 per ton in gold, silver, and lead, mainly in silver and lead, there being 8·26 per cent lead which was computed at 4 cents per pound. The total average values in the upper drift are slightly less than $10. The gold as a rule is quite low, but exceptional samples have been obtained that carried as much as 3 ounces per ton, and particularly well mineralized samples occasionally contain gold, silver, and lead to the value of $60 to $80 per ton.

Approximately 200 feet in elevation above the outcrop of the lower vein at the entrance to the upper drift, an 'upper vein' outcrops, which strikes about due east, and has an almost vertical attitude. This vein consists dominantly of quartz which carries more or less disseminated galena and pyrite with their oxidation products including lead carbonate which is quite prominent near the surface. An adit 35 feet long has been driven in to crosscut this vein, and from the end of the adit a drift has been run along the vein for about 75 feet in a southerly direction. The vein as exposed in the roof of the drift has a thickness of from 4 to 20 inches; and average samples taken across the vein at close regular intervals are claimed to contain from $5 to $18 per ton in gold, silver, and lead.

The ore material from these veins could not be shipped at a profit, as taken from the mine. It is, however, well adapted to concentrating operations and could be concentrated at least 7 to 1. The veins outcrop on the steep western face of Mt. Anderson between 1,300 and 1,800 feet above Becker creek opposite; and this hill-side affords a good site for a mill to which the ore could readily be conveyed from the mine workings by tramways or shoots. Becker creek affords ample water for milling and power purposes, and there is sufficient timber for all ordinary mining requirements for years to come in the valleys of Becker creek and Wheaton river, within a reasonable distance. A government wagon road has been constructed from Robinson on the White Pass and Yukon railway up Wheaton river, and a branch from this road continues up Becker creek to a point immediately below the outcrops of the veins on this property, a distance from Robinson of 25 miles. The railway has recently contracted to haul ore from the Whitehorse Copper belt to Skagway for $1.10 per ton, and the Whitehorse Copper belt is about 30 miles farther from Skagway than Robinson. From Skagway to the Tacoma or some other coast smelter, the rate on ore is from $2.00 to $2.50 per ton, making a total from Robinson of probably between $3.00 and $3.50 per ton. Additional haulage charges would have to be added for transport by road over the 25 miles from the mine to Robinson.

Antimony-Silver Veins

All the deposits of antimony ores that have been discovered in Wheaton district are appropriately included under the term antimony-silver veins, and mostly all of them occur on the western or northwestern slope of Carbon hill facing Wheaton river. One important vein of this type, however, occurs at the head of a tributary of Becker creek on the eastern side of Carbon hill, and two or three others have been found on Chieftain hill and in that vicinity, across Wheaton valley from Carbon hill. Most of these deposits have been previously described*, but since this district was last investigated, considerable development work has been performed on Carbon

*Op. cit., pp. 113-129.

hill, and the deposits there are much better understood than formerly. Also since the outbreak of the war, the demand for antimony has so increased that it is considered advisable to summarize the information concerning these deposits.

The antimony in the antimony-silver veins occurs dominantly in the form of stibnite (antimony sulphide), although some jamesonite (an antimony lead sulphide) is also found. These minerals are accompanied by galena, grey copper, zinc blende, and in some cases by arsenopyrite, which occur in a gangue composed mainly of quartz but including also some calcite and barite. Some of the veins contain important amounts of silver, but these are in most cases low in antimony, and, those high in antimony are as a rule low in silver. In a few places, however, both silver and antimony occur together in important amounts. The veins all occupy fissures in the containing rocks which are for the most part the Coast Range granitic intrusives. Occasional veins, however, are found in the Mesozoic andesitic rocks which are older than the Coast Range intrusives.

By far the greater number of the antimony-silver veins of Wheaton district, occur on the western face of Carbon hill, and of these nearly all are covered by a group of claims, that is here designated the Fleming property. A few other veins have been located on this slope of Carbon hill. The deposit on the east side of Carbon hill occurs on a claim owned by Messrs. Becker and Cochran, which is here termed the Becker-Cochran property. The deposits occurring on Chieftain hill and in that vicinity will be here so designated.

Chieftain Hill and Vicinity

The only vein of any importance that is known to have been found on Chieftain hill, is exposed in a prominent draw on the eastern face of the mountain, about halfway to the summit. Two claims named respectively the Morning and Evening claims were formerly located on this deposit*, but these have lapsed, and other locations have been made. Some development work was at one time performed on this vein, but when visited this past summer (1915), the cuts or trenches had so caved in as to completely obscure the outcrop. The vein occurs in a fissure in andesitic rocks, strikes about due west, and has a nearly perpendicular attitude. The deposit also consists chiefly of quartz which is in places well mineralized with stibnite, and carries also subordinate amounts of zinc blende. At one point the vein is 5 feet in thickness, 2 feet of which appears to be composed almost entirely of stibnite. The vein, however, narrows rapidly in each direction from this point.

An important vein carrying antimony minerals is reported to have been recently discovered on Berney creek, a short distance to the southwest of Chieftain hill, but this was not seen by the writer.

Fleming Property

A group of six mineral claims situated on the western or northwestern face of Carbon hill, is owned by Mr. W. J. Fleming of Chicago, who also holds a timber tract of 160 acres at the base of the hill below these claims. This group includes the claims formerly described as the Porter group**.

*Op. cit., p. 129.
**Op. cit., pp. 126-128.

Quite a number of veins have been discovered on this property, possibly between 15 and 20, the exact number being uncertain, due to the fact that in some cases insufficient development has been performed to make correlations sure, so that certain outcrops may belong to the same or different veins. The greater number of these veins occur in the Coast Range granitic intrusives, but a few are found in the Mesozoic andesitic rocks. The development includes not only a considerable amount of systematic surface work, but also about 1,100 feet of underground crosscuts and drifts. The veins range in thickness, in most places, from a few inches to 3 feet, although for short distances, some may be more than 3 feet thick, but even 2 feet is somewhat exceptional. The vein material, in places, contains as much as 50 per cent antimony, but average samples across the veins rarely carry more than 20 to 25 per cent, and in most cases contain less than 20 per cent. The gold content is prevailingly small in amount, rarely exceeding \$2 per ton, and being generally less than \$1. The silver and lead values are, however, quite important. Average samples across the veins contain occasionally 50 ounces or more of silver to the ton, but from 15 to 30 ounces is more representative of the richer silver veins, and in most places the average silver content ranges from a trace to 5 ounces. The lead in average samples rarely occurs in greater amounts than from 7 to 15 per cent, and in most cases under 5 per cent, and often under 1 per cent. The combined values in gold, silver, and lead, amount in rare instances to \$50 or more per ton, but from \$10 to \$20 is rather exceptional, and by far the greater number of average samples that have been taken from most of the veins run less than \$5 per ton. The samples taken from one or two of the best veins such as the 'big vein', however, average approximately \$10 per ton in gold, silver, and lead, i.e. without allowing for the antimony. These results are computed as the result of the assaying of upward of 300 samples by the Department of Mines, Ottawa, by the government assayer at Whitehorse, and by others.

Other Veins on the West Slope of Carbon Hill

The only other veins of any importance that are known to have been found on the west slope of Carbon hill, are the two parallel veins referred to in the writer's previous report as occurring on 'Goddell's claims'*. These veins occur about one mile to the north of the Fleming group, and are not more than 20 or 30 feet apart. They outcrop in a gulch and are distinctly exposed to view, extending up the mountain side for a distance of over 2,000 feet. They occur in the Coast Range granitic rocks, strike south 83 degrees west, and have an almost perpendicular attitude. The veins are 2 feet, and 2 feet 6 inches thick respectively, and consist chiefly of quartz which carries a certain amount of jamesonite and arsenopyrite, the antimony content being very low.

Becker-Cochran Property

A vein outcrop containing considerable stibnite is located on a claim owned by Theodore Becker and Howard Cochran, which is situated on the east side of Carbon hill, at an elevation of about 4,950 feet above the sea. This outcrop occurs near the head of a small northerly tributary of a creek locally known as Conglomerate creek which joins Becker creek from the

* Op. cit., pp. 128, 129.

west about 3 miles above its mouth. The vein is here possibly about 3 to 4 feet in thickness, but as it had not been stripped when visited and as the only work that had been performed had caved in, very little definite information was available. A number of large pieces of vein material from 1 foot to $2\frac{1}{2}$ feet in thickness were scattered along the outcrop of the vein, some of which appeared to be composed almost entirely of stibnite, and all contained considerable of this mineral. Two samples were taken from these masses or vein fragments. No. 1 is intended as an average of all the vein material in sight. No. 2 is an average of all the better mineralized pieces. These samples were assayed and found to contain:

Sample No.	Gold	Silver	Antimony
1	Trace	Trace	21·20%
2	Trace	Trace	40·62%

Conclusions

At present exceptionally high prices are being paid for antimony minerals, also the White Pass and Yukon Railway Company is now offering very low rates on ore shipments to Skagway to encourage the lode mining industry of Yukon. The antimony-silver ore would of necessity have to be sorted or concentrated before shipping, but in places limited amounts of shipping ore could be obtained by merely hand sorting. For any considerable tonnage, however, the ores would require to be concentrated. On Carbon hill very favourable natural facilities are provided for the erection of a concentrating mill, and a government wagon road has been constructed from Robinson to Carbon hill a distance of 30 miles, with a down grade all the way to the railway. It would thus seem practically certain that some of these veins could now be worked at a profit, particularly if a concentrator were erected in the near vicinity; and it is hoped these deposits will become producers in the near future.

Silver-Lead Veins

Veins of the silver-lead type are limited in their occurrence in Wheaton district, so far as is known, to one small area situated on the east slope of Idaho hill, facing Annie lake. These veins were formerly all located and covered by two groups of claims known as the 'Union Mines' and 'Nevada Mines'. Practically no work has been performed on these deposits since they were last examined so the reader is referred to the writer's former report* for descriptions of these deposits. There is undoubtedly a certain amount of fairly good ore contained in these veins, but it is doubtful if any of it is sufficiently high grade to pay for mining, shipping, and treatment, without concentration before shipment, and the veins do not appear to be sufficiently extensive or persistent to warrant the erection of a concentrating mill in their vicinity.

Coal

The only locality in Wheaton district in which coal has been found is

*Op. cit., pp. 129-139.

on Mt. Bush. There, several seams of semi-anthracite have been discovered, ranging from 18 inches to 6 feet or more in thickness. These seams have been very slightly explored or investigated, and little is known concerning them. They are, however, known to be considerably disturbed by basaltic dykes, several of which intersect them; this might nevertheless not seriously interfere with the economic working of these deposits which should be of value for local consumption, when the demand arises. For further details concerning these coal measures, the reader is referred to the writer's previous report*.

*Op. cit., pp. 145-147.

1916

Introductory Note

In 1916, W. McInnes, Directing Geologist, includes the following note on field work in Yukon Territory in the 'Introductory Statement' of the Summary Report for 1916, page 3:

"D. D. Cairnes spent the greater part of the field season in the Klotassin area, southern Yukon. From one creek in this area between 500 and 600 pounds of wolframite concentrate has been obtained from the auriferous placer deposits. Mr. Cairnes visited Dublin gulch, Duncan Creek mining district, for the purpose of investigating the possibility of the occurrence of scheelite in the placer deposits, and reports that scheelite was found to be relatively quite abundant. He also spent a short time examining some of the Windy Arm mining properties which during the past season were being reopened. Two days were spent examining certain 'alkali' deposits occurring along the Whitehorse-Kluane wagon road."

INVESTIGATIONS AND MAPPING IN YUKON TERRITORY

by D. D. Cairnes

The greater part of the last regular field season was spent in Klotassin area, southern Yukon; and a topographical and geological party was engaged there the entire summer. The area, including over 1,200 square miles, was mapped as to geology and drainage, and a special study was made of the mineral resources.

During the early part of August, the writer left camp in Klotassin area, went to Whitehorse, and from there spent two days examining and sampling certain saline incrustations which occur along the Whitehorse-Kluane wagon road, and which, it was thought, might contain important amounts of potash.

Later in the season the writer again left Klotassin area and spent a few days in Mayo area where the tungsten deposits in the vicinity of Dublin gulch were investigated, and a deposit of shell marl near Mayo was examined.

William E. Cockfield was senior assistant in connexion with the work in Klotassin area, and took charge of the field work there during the writer's absence.

At the close of the regular field season, a few days during the early part of October were spent examining lode deposits in the Windy Arm district.

Reports of the work in these four districts follow:

Tungsten Deposits of Dublin Gulch and Vicinity

During the past summer, while engaged in geological and topographical work in Klotassin area, Yukon Territory, the writer obtained information through the government assay office at Whitehorse, indicating the possibility of the occurrence of important deposits of scheelite on Dublin gulch. As the ores of tungsten are at present greatly in demand in connexion with the manufacture of munitions, arrangements were made at once to visit the locality. Accordingly, early in September a few days were spent in the vicinity of Dublin gulch, and it was found that scheelite occurs not only in important amounts in the stream gravels along Dublin gulch and some of its tributaries, but also in lode deposits which may prove to be of economic importance.

During the entire course of the investigation in Dublin gulch and in that vicinity, the writer was ably and voluntarily assisted by Mr. Robert Fisher, a miner and old-time resident in the district, and to him the writer wishes to express his sincere gratitude for information afforded, and for actual work performed.

Geographical Position

Dublin gulch lies within Duncan Creek mining district, in the part known as Mayo area[1]. It is a small stream about 4 miles long, and empties into Haggart creek, joining it from the northeast about 14 miles from its mouth. Haggart creek is one of the principal tributaries of McQuesten river, and has a length of over 20 miles.

Transportation and Accessibility

Mayo area, in which Dublin gulch is situated, is fairly readily accessible. Stewart river generally opens between May 10 and 15, and remains clear of ice until some time in October. During the season of open navigation, a steamer with good passenger and freight accommodation makes weekly trips from Dawson to Mayo, a distance of 238 miles. During the winter months, there is a monthly—and for part of the time, a bi-monthly—overland stage service between Dawson and Minto Bridge, a small village 10 miles north of Mayo, at the junction of Minto creek and Mayo river. The distance from Dawson to Minto Bridge over the stage road is 174 miles. Mayo and Minto Bridge thus are the distributing points for Mayo area. From Mayo, a good wagon road has been constructed by the Yukon Government, to Minto Bridge, with a branch extending to the mouth of Dublin gulch, a distance of 35 miles, or 45 miles from Mayo; but for only about 6 miles of the 35, is the road good enough for summer freighting. For the remainder of the distance the road is so rough and soft it is almost impossible to drive over it in summer, even with a light buckboard. Thus all freighting over this road must necessarily be done in winter when it would probably cost about $35 or $40 per ton to take concentrates or ore from Dublin gulch to Mayo. From Mayo, ore has recently been shipped to San Francisco by the all-water route via St. Michael for about $22 per ton, so the rate to Vancouver would be between $15 and $20 per ton. The regular rate charged by the Side Streams Navigation Company on in-going freight from Dawson to Mayo is 2 cents per pound.

History

Dublin gulch with the immediately surrounding portion of Yukon Territory has been reported upon at different times. In 1904, Joseph Keele, of the Geological Survey, made a reconnaissance survey and geological examination of a portion of Duncan Creek mining district including Dublin gulch[2]. In 1912, Mr. T. A. MacLean, on behalf of the Mines Branch of the Department of Mines, examined the lode deposits on Dublin gulch[3]. In

[1] Cairnes, D. D., "Mayo Area", Geol. Surv., Canada, Sum. Rept., 1915, p. 10.

[2] Keele, Joseph, "The Duncan Creek mining district," Geol. Surv., Canada, Sum. Rept., 1904, pp. 18A-42A.

[3] MacLean, T. A., "Lode mining in Yukon", Mines Branch, Dept. of Mines, Canada, 1914, pp. 127-159.

1915, the writer made a preliminary examination of Mayo area, including Dublin gulch, with the expectation of completing the investigation the following summer[1]. Keele mentions the presence of scheelite on Dublin gulch. He states, "The gold on Dublin gulch..........is accompanied by a quantity of heavy white sand, consisting of rounded grains of scheelite (tungstate of lime), from which it is difficult to separate the gold".[2] Hoffmann[3] examined and described the material collected by Keele. The placer miners of that vicinity, although they knew that what they termed 'grey sand' occurred on Dublin gulch in considerable quantities, did not know its value, and recognized it only when it was obtained in the sluice boxes, in a finely comminuted condition. For this reason, many tons of rich tungsten ore concentrates have no doubt been lost in the placer mining operations along this creek.

In 1898, John Suttles commenced placer mining on Dublin gulch, and he continued to work more or less each summer until the autumn of 1915, during which time, it is estimated by the old-timers in that locality, that he must have recovered in all between $45,000 and $50,000 in gold. On August 30, 1905, a concession for placer mining on Dublin gulch, generally known as the W. E. Thompson concession, was granted and recorded as hydraulic mining lease No. 47. This is described as follows:

"All and singular that certain parcel or tract of land situate, lying and being in the Yukon Territory on Dublin creek, described as follows: Commencing at a point on said creek 1,360 feet more or less, up stream from its junction with Haggart creek, a tributary of the McQuesten river, thence up said Dublin creek 3·21 miles, more or less, with a width of one-half mile on each side, excluding thereout and therefrom any placer mining claims for which entries may have been granted, and which may be in force on the day of these presents, as shown on plans of survey thereof dated the 30th of November and the 7th of December, 1903, signed by George White-Fraser, D.L.S., and of record in the Timber and Mines Branch of the Department of the Interior."

Previous to the granting of this concession, John Suttles had located about 2,500 feet of Dublin gulch, near the lower end of what afterwards became the concession, and this ground was not, therefore, included in the grant. Practically all the placer mining that has been done on Dublin gulch has been on the Suttles claims. Accordingly, as the owner of the concession did not work his ground as required by the terms of the lease the concession was cancelled and steps have been taken to throw the ground open to the public. Since it has become known that scheelite occurs in important amounts on Dublin gulch, a number of placer claims have been staked on its tributaries outside the boundaries of the concession. Also some lode claims supposed to cover deposits of scheelite have been recently located.

Between the close of the summer season of 1915, and the opening of the past season (1916), the holdings of John Suttles on Dublin gulch were acquired by Cantin Bros., who mined the ground during the past summer. They worked by ground sluicing, and with three men working, cleaned up altogether about $6,000 in gold. They commenced to systematically save the scheelite concentrate after the writer's visit, and report that since that

[1] Cairnes, D. D., op. cit., pp. 10-34.
[2] Keele, Joseph, op. cit., p. 33A.
[3] Hoffmann, G. C., Geol. Surv., Canada, Ann. Rept., vol. XVI, 1904, p. 340A.

time, they have been able to recover about 400 pounds a week, with very slight additional time or labour.

General Geology and Topography of the Mayo Area

Mayo area lies entirely within the Yukon plateau physiographic province, and is mainly characterized by being subdivided by well developed, flat-bottomed, interlocking valleys, into numerous small, isolated mountain groups and areas of well dissected upland. The higher summits rise to elevations of from 5,000 to over 6,500 feet above sea-level—Mayo village being considered to be 1,625, and Mayo lake, 2,000 feet above the sea. The former plateau surface has been largely destroyed in this district, and the shapes of the land forms, except where modified by glaciation, are for the most part dependent on the geological formations. The district has been, on the whole, intensely glaciated, the glacial ice, at one time, extending over practically the entire area, and enveloping all except possibly the highest summits. As a result, the valley walls have become smoothed, planated, and steepened, giving to the valleys, typical U-shaped cross-sections. In addition, the floors of the master valleys have become deeply covered with glacial detritus, which in post-Glacial time has been trenched and in part removed by the streams of the district.

In the vicinity of Dublin gulch quite extensive stretches of gently rolling upland are preserved which have a general elevation of about 1,900 feet above the mouth of Dublin gulch. Potato hills at the head of Dublin gulch are somewhat higher, and are estimated to rise to 5,400 feet above sea-level. The valley of Dublin gulch has been considerably modified by glacial action, thus the creek gravels in the valley bottoms contain more or less foreign material. The upland in this vicinity, and even the upper portions of the valley walls, on the other hand, have been only slightly affected, and foreign pebbles or boulders are there somewhat exceptional.

The geological formations exposed throughout the greater part of Mayo area are dominantly old, metamorphosed sediments, including mainly mica schists, quartz schists, and schistose quartzites, with also some beds of crystalline limestone. These correspond to certain of the old, schistose rocks of the Klondike*, and other portions of Yukon and Alaska, and belong to the Yukon group** which is thought to be of Pre-Cambrian age. In the vicinity of Dublin gulch, a small granitic batholith some 3 or 4 miles in length cuts these older rocks, and includes all the upper portion of the creek and its upper tributaries. This granitic intrusion is composed mainly of grey biotite granites, thought to be of Mesozoic age.

Tungsten

In the vicinity of Dublin gulch, the principal tungsten-containing mineral that has so far been found is scheelite. Occasional particles of wolframite were also noted in the concentrates obtained in the placer mining operations there, but this mineral does not occur in amounts of much economic importance.

Scheelite ($CaWO_4$) is calcium tungstate, and contains 80·6 per cent

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*McConnell, R. G., "Report on the Klondike Gold Fields," Geol. Surv., Canada, Ann. Rept., vol. XIV, pt. B, 1905, pp. 12B-15B.

**Cairnes, D. D., "The Yukon-Alaska International Boundary between Porcupine and Yukon rivers", Geol. Surv., Canada, Mem. 67, pp. 38-44, 1914.

of tungsten trioxide (WO_3), and 19·4 per cent of lime. It has a hardness of 4·5 to 5, i.e., it is about intermediate in hardness between calcite and an average feldspar. Its lustre is vitreous inclining to adamantine, and its colour is generally white, yellowish white, or pale yellow. Brownish, greenish, and reddish varieties occur, but are rare. The scheelite of Dublin gulch is white to pale yellow in colour. Possibly the most diagnostic physical property of scheelite is its specific gravity which is 5·9 to 6·1, or considerably higher than that of magnetic iron ore.

Wolframite is the tungstate of iron and manganese. Its hardness is 5 to 5·5, its specific gravity is 7·2 to 7·5, and its colour is dark greyish or brownish black. The streak is nearly black. Wolframite is generally readily recognizable by the brilliant sub-metallic lustre, on its characteristically perfect cleavage faces. It resembles specular hematite, but is much heavier.

In describing tungsten and its uses, Dr. Walker in his report published in 1909, states: "Tungsten is one of those rare metals which have become generally useful during the last few years. Formerly it was of interest chiefly because it was one of the rare chemical elements. Of late it has become an article of commerce and industry, and has attracted much attention on the part of iron masters, dyers, silk workers, electricians, and especially of those connected with the mining industry. Being one of the most infusible metals known it has been recently employed in the manufacture of incandescent electric lamps. The tungsten filament has the advantage over the ordinary carbon filament of yielding a much whiter light. When carbon filaments are heated to a brillant white, a black smoky deposit of volatilized carbon forms upon the interior of the bulb so that much of the light efficiency is lost; while the tungsten lamp will stand this white incandescent condition without any appreciable deterioration. Apart from this advantage, the manufacturers of the tungsten bulbs claim for their product a greater light efficiency for the electric energy consumed, even when compared with new, undimmed carbon bulbs. Considerable quantities of tungsten are consumed in the manufacture of tungstates, which are used as a mordant in dyeing, in giving weight to silk goods, and in rendering cotton fabrics fireproof. The chief demand for tungsten, however, is for the production of tungsten steel, which is also called wolfram steel. The addition of a small percentage of this metal increases the elastic limit and tensile strength. Tungsten steel is self-hardening, so that no special skill is required on the part of the blacksmith in the sharpening of tools made from it. Tools which have been heated are found to be well tempered as soon as they cool. These properties make this alloy very desirable for high speed tool steel."* Since the war there has been a great demand for tungsten for use in the manufacture of high speed cutting tools employed in the manufacture of munitions.

At the beginning of the war, the Imperial Government placed a price on all tungsten ores within the British Empire, and prohibited their export. The price paid per gross ton (2,240 lb.) of 65 cents per WO_3 ore is at the rate of 55 shillings per unit (1 per cent of 2,240 lb.) per gross ton f.o.b. Liverpool, less charges as per H. A. Watson's pro forma contract. The price thus fixed amounts to about $853 per ton without considering insurance or freight. A penalty of 6 cents per unit down to 60 per cent WO_3 is imposed.

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*Walker, T. L., "Report on the tungsten ores of Canada," Mines Branch, Dept. of Mines, Canada, 1909, pp. 3, 4.

Economic Investigation

Investigating the occurrence of scheelite on Dublin gulch, and prospecting for its source, were at first found difficult, owing to the fact that scheelite is not a readily recognizable mineral, especially when finely subdivided. In places it is even difficult to distinguish from quartz, feldspar, or other white or nearly white minerals. Therefore, in addition to the ordinary physical, chemical, and specific gravity tests, panning was found to be a very efficient and rapid auxiliary method for detecting this mineral either in gravel, or pulverized rock or ore material. Owing to its high specific gravity, very minute particles of scheelite can be saved by panning almost as readily as gold, and can then be easily identified.

It was found that the stream gravels along Dublin gulch contain important amounts of scheelite. Scheelite also occurs below the mouth of Dublin gulch in the gravels of Haggart creek, for some distance, but not to nearly the same extent as along Dublin gulch, from where it is clear, practically all of the mineral is derived.

Previous to the writer's visit, the mineral scheelite, as such, was quite unknown to the miners of Dublin gulch and vicinity, but the so-called 'grey sand' which collected in the sluice boxes, and was difficult to dispose of, had recently been discovered to be of value and some had been saved. Also, places were found where this 'grey sand' had been dumped from the sluice boxes in past years. Altogether, about a ton was found to be available. Two samples (A and B) of these concentrates were taken. No. A is a sample from a pile containing about 300 pounds, which was dumped where it lay, several years ago. This sample was assayed at the ore testing plant of the Department of Mines, Ottawa*, and was found to contain 68 per cent WO_3 (tungsten trioxide). No. B is a sample from a lot of about 800 pounds of concentrates that had been recently collected. This was assayed and found to contain 66.30 per cent WO_3. Associated with the placer gold and scheelite, there occurs a certain amount of heavy, dark concentrate including wolframite, cassiterite (tin stone), hematite, and garnet. These minerals when plentiful are somewhat difficult to separate from the scheelite in the sluice boxes. When visited in September Cantin Bros. had saved about 200 pounds of this dark concentrate, and a sample from this was assayed and found to contain 61.20 per cent WO_3.

About 2 miles of Dublin gulch that is adapted to placer mining is still virgin ground, and should yield gold and scheelite in somewhat similar amounts to the 2,000 feet or so that have been worked. Along the part of the creek that has been mined, the gravels and overburden are, together, in most places, from 6 to 20 feet in thickness. The upper portion of Dublin gulch, commencing about $2\frac{1}{2}$ miles from its mouth, could not be worked by ordinary placer methods owing to the fact that the valley bottom is strewn with vast quantities of a coarse granite talus, many of the individual blocks being as much as 6 to 20 feet in diameter. In addition to the main creek, it will probably be found that some of its tributaries will pay to mine, now that scheelite is known to occur in this vicinity in addition to the gold.

An attempt was made to determine the bedrock source of the scheelite. It was found that all gravels derived from the granitic rocks in the vicinity contain important amounts of this mineral, although no scheelite could be

* All assays, the results of which are given in this report, were made at the ore testing plant of the Department of Mines, Ottawa.

detected in the ordinary unaltered granite. Well up on the hillsides, and even on the upland, where the ordinary more or less decomposed granitic overburden is practically in place and unconcentrated it contains scheelite in appreciable amounts. The schistose rocks, on the other hand, yield little if any of this mineral. Places were found near the heads of some of the smaller tributaries of Dublin gulch, where the gravels of granitic origin yielded as much as 1 per cent scheelite or over one pound of scheelite concentrate from 100 pounds of gravel. A sample of about one pound of scheelite concentrate, obtained in panning four pans of gravel near the head of Bum Boy gulch, was assayed and found to contain 63.80 per cent WO_3. The total amount of scheelite in the vicinity must, therefore, be very great. In places even near the extreme heads of some of the smaller tributary streams where water is rather scarce, it is estimated that men working with rockers or cradles could make more than wages from the scheelite alone.

There are a number of important gold-bearing quartz veins in this vicinity*, some of which have been quite extensively developed. It was at first thought that the scheelite might be associated with these veins, but little or none was found in them. Scheelite was eventually found at one point with its original associations, and there the bedrock was covered by several feet of overburden, making prospecting slow and difficult. At that point the scheelite is associated with small, barren, ramifying quartz veinlets which occur very plentifully intersecting pegmatitic zones within the granite. The scheelite, where found, occurs in the form of crystals along the edges of and between the veinlets, the individual crystals being as much as 0·3 to 0·5 inch in length. In all probability this is the manner in which most of the scheelite of the district occurs. It is quite possible, with further prospecting and investigation, that zones will be found in this vicinity which will pay to work as lode deposits. A sample of vein material from this locality recently forwarded to the writer by Robert Fisher was assayed at the ore testing plant in Ottawa and found to contain 5·70 per cent WO_3, which is indeed very promising.

Summary and Conclusions

Two main factors will somewhat retard the rapid development of mining on Dublin gulch and in that vicinity; these are the limited water supply for placer mining, and the remoteness of the district. The extent of the placer mining operations will be always limited by the available supply of water. However, by conserving and making the most economical use of all the water in Dublin gulch and its tributaries, very much more work can be done than has been done in the past. Owing to the remoteness of the district, also, it is difficult and expensive to freight in supplies and equipment, and the output of scheelite or other ores can at present be freighted out only during the winter when the sleighing is good. The cost of building a suitable summer road is at present, at least, almost prohibitive. This means that the scheelite concentrates which were mined during the summer of 1916 will be freighted to Mayo during the following winter and will not be available until after navigation opens in the early summer of 1917; and that

* MacLean, T. A., "Lode Mining in Yukon," Mines Branch, Dept. of Mines, Canada, 1914, pp. 127-159. Cairnes, D. D., "Mayo area, Yukon Territory," Geol. Surv., Canada, Sum. Rept., 1915, pp. 29-33.

concentrates recovered during the summer of 1917 will not be available until the summer of 1918.

During the writer's visit to Mayo area, every effort was made to instruct the miners and prospectors of the district in the physical characters of the tungsten minerals and the simple tests for determining them; also specimens of scheelite and wolframite were distributed to those most interested.

Between $1\frac{1}{2}$ and 2 tons of scheelite concentrates, similar to those sampled, should be freighted to Mayo this winter, and be available early next summer. Next season, also, when the concession on Dublin gulch has been thrown open for staking, if the locators work diligently throughout the season, it is reasonable to expect that at least between 10 and 20 tons of tungsten concentrates in addition to the gold will be recovered. In fact, it would now appear as if Dublin gulch is destined to become an important Canadian source of tungsten ore.

Marl Deposit Near Mayo

While waiting at Mayo for a steamer in September, 1916, the writer examined a greyish deposit of shell marl exposed around a lake in the vicinity. The lake lies along the wagon road running from Mayo to Minto Bridge, and is about 2 miles from Mayo. The level of the water is being gradually lowered as the drainage of the district becomes integrated, and the lake is gradually filling with marl which has resulted from the accumulation, and more or less complete disintegration of many generations of freshwater shells, the marl being exposed all around the lake, and on the islands within it. The area covered by the water and the marl rim is apparently between 1 and 2 square miles. The marl deposit is very soft, and is apparently thick as it is possible at the water's edge to easily push a stick down into it to a depth of 10 feet. Evidently, the entire lake is underlain by the marl which may also extend farther back from the water's edge than appears. Around the lake, a reddish, clayey soil, several feet in thickness, extends back for about a mile beyond the marl rim.

Four samples of the marl and soil were taken. These were air-dried and analysed, with the following results:

Analyses of Marl and Soil from Mayo

	I	II	III	IV
Moisture	16.00	9.04	5.66	4.75
Organic and volatile matter	23.51	24.03	1.66	1.34
Mineral matter insoluble in acid	6.55	6.75	24.91	36.60
Carbonate of lime	49.90	54.39	53.19	45.91
Undetermined	4.04	5.79	14.63	11.40
	100.00	100.00	100.00	100.00
Nitrogen, in organic matter	0.84	0.75	0.16	0.20

I. Surface sample of marl, taken near the water's edge, and containing many small shells.
II. Sample of the upper 3 feet of the marl.
III. Sample of the reddish, clayey soil, a few feet back from the water's edge and the grey marl rim, and containing apparently no shells.
IV. Sample of the lighter, reddish soil, higher up and less closely associated with the marl.

Analyst, Dr. Frank T. Shutt, Dominion Experimental Farm, Ottawa.

Dr. Shutt states: "Traces only, of phosphoric acid were detected in all the samples. All four samples are marl of fair quality, the carbonate of lime content approximating 50 per cent. Their agricultural value would, therefore, be in furnishing lime for soils deficient in this element and in correcting soil acidity. Samples I and II also contain notable amounts of vegetable matter and nitrogen and their application would, therefore, prove useful for all types of soil more or less poor in these important soil constituents."

This marl is too impure to be of value for the manufacture of cement, but is of considerable importance for agricultural purposes, and in Mayo area and adjoining portions of Yukon, agriculture, it is hoped, will in the near future be followed much more extensively than at present, as wide tracts of valley lands are well adapted to agricultural pursuits.

The part played by lime and its compounds in maintaining and increasing soil fertility is an exceedingly important one; and, chiefly because they may be readily and uniformly distributed over the land, the marls constitute a very useful form of carbonate of lime for agricultural purposes, and one the value of which Canadian farmers have not yet sufficiently recognized. The functions and use of marl in agriculture, and also some methods of testing for acidity in soils are described by Dr. Shutt.* According to Dr. Shutt there are two principal reasons for applying lime to soils, viz., to correct or neutralize their acidity or sourness, and to improve their mechanical condition. The influence of lime and its compounds upon the texture of the soils is most beneficial in the case of clays, rendering them less sticky and cohesive, when wet, and more friable and mellow when dry. The excessive use of quick-lime or slaked lime leads inevitably to exhaustion of fertility, and, therefore, they must be carefully applied. Excess of marl, however, can do little or no harm. The application of marl offers no special difficulty; a spreader may be used or the material may be distributed by shovels from a wagon. It may be applied at any season of the year, and it is specially suited to light loams and soils that are poor in organic matter. Like lime, it should be harrowed in, not ploughed under, and in the case of meadows or pastures, merely spread over the surface.

Klotassin Area

The greater part of the summer (1916) was spent in Klotassin area, southern Yukon. The area was considered to be favourably situated for the occurrence of various kinds of mineral deposits, and as it was almost entirely unknown geologically, topographically, or even geographically it seemed desirable that it be explored. Further, during the previous summer, placer gold had been found on Rude creek, which drains into Dip creek, a tributary of Klotassin river, with the result that a stampede followed, and not only Rude creek, but a number of other creeks in the neighbourhood were staked, and some prospecting and mining resulted. There followed numerous rumours of important discoveries, but it was not known how authentic these reports were. Possibly the most urgent reason for an investigation of this section of Yukon, however, was the finding of tungsten concentrates on Canadian creek. At the close of the field season of 1915, the writer

* Shutt, Frank T., "Lime in agriculture", Dept. of Agriculture, Dom. Exp. Farm, Ottawa, Bull. No. 80, 1914.

recognized the presence of wolframite (tungstate of iron and manganese (Fe, Mn) WO_4) in samples of concentrates from placer mining operations on Canadian creek, shown him by a prospector. These samples were examined in the mineralogical laboratory of the Geological Survey, and found to be very high grade tungsten concentrates. As there has been since the beginning of the war an urgent need for tungsten for use in the manufacture of munitions, this occurrence demanded investigation. Canadian and Rude creeks, also, are not far apart, the mouth of Rude creek being within about 6 miles, measured in an air line, of the point near the head of Canadian creek at which the wolframite has been found to occur most plentifully. It was, therefore, decided to explore and map the area containing Rude and Canadian creeks, and to extend the work in whatever direction seemed most advisable from a mining and geological standpoint. The particular area mapped during the summer, since it is to a great extent drained by Klotassin river, is in this report called Klotassin area.

The drainage and geological features were mapped by running numerous traverses. No attempt was made to make a contoured topographical map. The left bank of Yukon river was traversed from Selkirk down to the now unoccupied telegraph station near Coffee creek. Another main traverse was run from the mouth of Isaac creek on this river traverse, to a point near the mouth of Klotassin river, the geographical position of this point having been previously fairly closely determined. Another traverse was carried from this point to connect with the Coffee Creek telegraph station again. The valley of the Klotassin was traversed from the mouth of the river to near its head; in addition, all the main stream valleys in the area were traversed and numerous cross traverses were run to connect the main lines. These traverses were made in three ways. The main traverses, where possible, were run with plane-table, rod, and stadia; at times, instead, a measuring wheel was used in conjunction with a small plane-table or a Batson sketch board mounted on a tripod; and for the less important, shorter, connecting traverses, pacing was employed in conjunction with a small plane-table or Batson sketch board.

In the performance of this work, the writer, as well as all the members of his party, were assisted in many ways by the different men met within the district, and were assured by all of their entire and hearty co-operation wherever possible. Particular thanks are due G. C. McDonald and E. H. Shafer who during different parts of the summer held the position of government telegraph operator at Isaac creek. They stored the supplies and surplus outfits belonging to the party, looked after the mail, and in many ways rendered valuable and always voluntary assistance. For all courtesies and favours received, the writer wishes to express his sincere thanks.

Throughout the work, the writer was very ably assisted by William E. Cockfield, Clive E. Cairnes, and J. A. McLennan. Mr. Cockfield devoted his time almost exclusively to geological work, and Mr. Cairnes and Mr. McLennan, although assisting with the geology at times, were mostly employed with the topographical work.

Location and Accessibility

Klotassin area is bounded on the north by Yukon river, and extends along the river from a short distance above the mouth of the Selwyn, to a mile or so below the mouth of Coffee creek, a distance measured along the river of about 35 miles. From Yukon river below Coffee creek, the western boundary extends in a southwesterly direction to Donjek river, a distance of about 30 miles; thence the southern boundary trends in a direction somewhat south of east for between 35 and 40 miles to a point on Klotassin river near its head; and thence the eastern boundary reaches northward to Yukon river again, a distance of between 35 and 40 miles. The area includes over 1,200 square miles.

During the season of open navigation the northern edge of the district is easily accessible from Yukon river, several commodious freight and passenger steamers passing up and down the Yukon between Whitehorse and Dawson each week. Gasoline launches, of a type specially designed and built in Yukon for side-stream work, also can readily run from Yukon river up the White and Donjek to the mouth of the Klotassin. From three points on Yukon river, trails have been built southward into the interior of the area. From near the mouth of Coffee creek, a trail extends up this stream, and thence to Klotassin river, a distance of about 30 miles. This trail, which is known as the Coffee Creek trail, continues thence to Upper White River district.* Another trail extends from Yukon river up Britannia creek to the mouth of Canadian creek, and thence continues up Canadian creek for about 5 miles. Above this point on Canadian creek there is a trail for a few miles, but it is very difficult to travel with pack-horses. Also several trails have been made from the mouth of Isaac creek over the divide to Rude creek; these follow two main routes, one of which leads to the mouth of Rude creek, and the other to a point near its head, distances from the mouth of Isaac creek of about 16 and 14 miles respectively. A trail extends down Rude creek for about 5 miles to connect the Isaac Creek trails, and continues thence down Dip creek for about 6 miles. These include practically the only trails in Klotassin area, and they are, for the greater part, very difficult to travel, being rough and very soft, since the valleys through which they pass are dominantly wet and floored with muskeg and niggerheads. During the winter, the area is readily accessible with sleighs from Yukon valley.

Topography

Klotassin area lies well within that physiographic province known as the Yukon plateau, which extends from about latitude 59 degrees north, in northern British Columbia, through central Yukon and Alaska to Bering sea. This plateau terrane has been described by a number of geologists among whom there appears to be a consensus of opinion that it represents a region which during a long period of crustal stability was extensively planated and reduced to a condition of relatively slight relief. The period of planation was followed by a widespread uplift when the nearly flat or gently undulating lowland became an upland tract. This uplift rejuvenated the streams, giving them renewed head, and increased erosive power, with the result that they commenced immediately to rapidly incise and deepen their channels in the new upland, and to destroy its surface.

In Klotassin area extensive tracts of nearly flat or gently undulating plateau occur separated by intersecting stream valleys; and to an observer stationed on the upland, it is evident that these plateau areas were once all connected to form a single, continuous surface of only slight relief. So

*Cairnes, D. D., "Upper White River district, Yukon", Geol. Surv., Canada, Mem. 50, 1915, pp. 11, 12, and "Canadian routes to White River district, Yukon, and to Chisana district, Alaska," Geol. Surv., Canada, Map. 113A, 1914.

situated, and well back from the edges of the valley walls, it is easy for one to imagine the intersecting valleys again refilled, or to forget that they have ever been incised to interrupt the continuity of this plateau surface. The main upland has now a general average elevation of between 4,500 and 4,800 feet above the sea, the mouth of Klotassin river being about 1,900 feet above sea-level. Occasional residual summits rise above the general plateau surface, the highest of which are about 6,300 feet above sea-level. The northern portion of Klotassin area is drained by northward flowing streams including Coffee creek, Excelsior creek, Britannia creek, Isaac creek, Mascot creek, and Selwyn river, which empty directly into the Yukon. The remainder of the area is drained by Klotassin river and its tributaries which have a general westerly trend, and empty into Donjek river, a tributary of White river. Between the Klotassin and its tributaries, and those streams emptying directly into the Yukon, there is a long, high, persistent, flat-topped divide which swings in semi-circular form around the headwaters of the Klotassin. One notably long and flat-topped arm of this range lies between Colorado creek and Klotassin river on the south, and Victor and Dip creeks on the north, and extends westerly to near the point where Dip creek joins the Klotassin. Numerous ridges lying between the different streams emptying into the Yukon reach toward this river from the main plateau divide. These smaller ridges are irregular in form, and gradually become lower in elevation as the Yukon is approached, the original upland being there in most places entirely destroyed. To the south of the main divide, the plateau surface is better preserved, but is largely destroyed in the vicinity of the master depressions.

The district shows no evidence of glaciation. The valleys contain interlocking spurs, and the valley walls exhibit none of the rounding, smoothing, and scouring, diagnostic of glaciated areas. The smaller depressions are also decidedly V-shaped, although the master depressions have in places wide floors. The valley walls are prevailingly steeply inclined, being often quite precipitous, indicating a somewhat youthful stage in the physiographic history of the district. Even the valley of Yukon river in this locality is of comparatively recent origin.

In the valley bottoms of the area superficial deposits tend to accumulate somewhat rapidly, due to the fact that the material contributed by the tributaries is largely frozen before it can be carried away by the streams in the valleys, and after becoming frozen its removal is very slow and difficult. On this account, mainly, the valleys of Klotassin river and its main tributaries are gradually being refilled. Overlying the other superficial deposits in the valley bottoms, is nearly everywhere, a layer of soil or muck which is covered with moss, grass, or shrubbery, and is transformed into muskeg and niggerheads, making travelling very laborious.

The main stream in Klotassin area, except the Yukon, is Klotassin river. This stream was not followed quite to its head, but from what is known concerning it, the main valley is thought to be about 60 miles long. Throughout the upper portion of its course, as far as it was explored, the river flows in a general northerly direction, but about 25 miles from its mouth, it makes a sudden turn and below this bend flows in direction almost due west. Several large tributaries join this stream, the most important coming from the right (looking downstream). Three of the largest of these are Dip, Colorado, and Somme creeks. These all hold a general westerly course, Dip creek being about 30 miles long; Colorado and Somme creeks were only explored to points about 12 and 8 miles respectively from the Klotassin, but at these points they were still important streams.

Vegetation

The forest growth of Klotassin area is nowhere heavy; trees, however, grow on nearly all the valley floors, as well as in the draws and on the hill-sides, up to an average elevation of between 3,500 and 4,000 feet above sea-level. In general, about one-third to one-half of the district is forested, the northern and eastern slopes being better timbered than the southern and western. Only in the valley bottoms, however, and in occasional draws, do trees occur sufficiently large to be used in the construction of buildings or in connexion with mining operations, except as fuel. The largest and best timber in the district occurs or did occur in the valley flats along Yukon river, but much of this has now been cut and used as fuel on the river steamers. In the valley bottoms of Klotassin river, Dip creek, and Colorado creek there are also many groves in which the trees are tall and stand fairly close together. Altogether, although timber is nowhere very plentiful, there is sufficient that is reasonably accessible to most points to fulfil the ordinary requirements of the miner for a number of years to come. During the past summer, however, much good timber was destroyed by forest fires, which were the result of carelessness and neglect.

The principal forest trees are: white spruce, black spruce, balsam poplar, aspen poplar, and northern canoe birch. There are also a number of shrubs some of which in places attain the dimensions of trees; these embrace several species of willow, one or more of alder, and dwarf birch.

The white spruce is the largest, and much the most useful and important tree, and as well, is the most plentifully distributed of the larger forest members. It grows at all elevations up to timber-line, but favours dry slopes and well-drained portions of the valley bottoms. The best groves generally occur in the valley flats and in depressions along the lower slopes of the ridges and in such locations the trees are straight and well grown. The trunks are generally not more than 12 to 18 inches in diameter 3 feet from the ground, but groves occur in which specimens with 24-inch stumps are fairly plentiful. This tree furnishes strong easily worked timber, and is well suited to the usual needs of the miner, and for purposes of construction generally. Black spruce occurs associated with the white spruce mainly in peat bogs or other poorly drained portions of the valley bottoms, and on the lower hillsides, particularly those facing the north, but it is not as large or well grown as the white spruce. Aspen poplar and balsam poplar constitute a large portion of the forest growth both in the valleys and on the hillsides. Balsam poplar grows best along the alluvial flats of the main valleys, while aspen extends higher up on the drier hillsides. Specimens were seen in all stages of growth from small shrubs to trees 10 to 14 inches in diameter or even larger. The poplars make good fuel if the wood is properly cured, but they are too soft and generally too irregular in form to be of any use for constructional purposes. The northern canoe birch, which is nowhere very plentiful, is seldom more than 8 to 10 inches at the stump, and is of value mainly as fuel. Willows, alders, and dwarf birch constitute the greater part of the shrub growth of the district. The willows are plentiful in the valleys, but do not in most places extend far above the level of the larger streams. The dwarf birch occurs chiefly in the higher valleys, and along the upper slopes near timber-line, and in places extends well over the upland. The alder occurs associated with the willows and birch, extending well above the tree-line to practically the shrub limit, and in places along the mountain slopes it is found practically unassociated with other varieties of shrubbery.

The valley bottoms of Klotassin river, Dip creek, and Colorado creek, as well as of some of their larger tributaries, are in places quite open and are covered with luxuriant growths of grasses which would constitute good fodder for horses or cattle. Some of the best meadow lands occur in Klotassin valley for 10 miles above the mouth of Dip creek; also in the valley of Dip creek between the mouths of Rude and Victor creeks; and in Klotassin valley below the mouth of Dip creek. The flats of these valleys range in width from half a mile to 3 or 4 miles, and constitute important extents of meadow or pasture lands.

Game

Big game abounds in Klotassin area, moose and bear being particularly numerous and sheep and caribou also inhabit parts of the district. The moose are the large giant moose; these magnificent animals are to be seen almost anywhere throughout the area, but range mainly in the lowlands, and are particularly plentiful in the valley flats of Klotassin river, Dip creek, Victor creek, and Colorado creek. The bear are mainly a very large brown variety, and are exceedingly numerous, particularly within the portion of the area drained by Klotassin river. The caribou are mainly the large woodland variety, and are fairly plentiful on the low open hills in parts of the district. The sheep are the white Alaskan variety; they feed during the winter months in the main valleys, but with the approach of summer, work farther and farther back into the higher mountains and choose especially the lofty, rugged, craggy summits.

Rabbits which were very plentiful in southern Yukon until a year or so ago, are now very scarce, and in Klotassin area very few were seen last summer. The chief fur-bearing animals in the district are lynx, mink, marten, wolverine, and red fox which are fairly numerous in places; cross, silver, and black foxes also are occasionally found.

The chief game birds are rock ptarmigan, willow ptarmigan, Alaska spruce partridge, fool hens or Franklin grouse, sharptailed grouse, geese, and various varieties of ducks. The ptarmigan are reported to have been very plentiful until the past two summers, but now they as well as the grouse are very scarce. Ducks are fairly plentiful on some of the lakes in the valley flats.

The streams and small lakes are generally well stocked with fish, chiefly grayling. In Yukon river other varieties of fish also occur, including mainly salmon and pike.

General Geology

The geological formations exposed within Klotassin area range in age from probably Pre-Cambrian, to Recent, and include both sedimentary and igneous members. Some metamorphic rocks of somewhat obscure origin also are present. The most extensively developed terrane of consolidated rocks is a granitic batholith, probably of Cretaceous or Jurassic age, which reaches completely across the area, and extends an unknown distance beyond in both directions. The next most important geological formation is composed entirely of metamorphic rocks, probably all of Pre-Cambrian age. These rocks embrace members of both sedimentary and igneous origin. They are characteristically schistose and gneissoid in character, but include some beds of massive crystalline limestone. The other consolidated geological formations of Klotassin area, are dominantly volcanic rocks ranging in age from early Mesozoic to, probably, fairly late Tertiary; they are for the greater part, semi-basic to basic in character, and include chiefly andesitic and basaltic members.

Table of Formations

Era	Period	Formation	Lithological Character
Quaternary	Recent and Pleistocene	Superficial deposits	Gravel, sand, clay, silt, soil, muck, ground-ice.
Tertiary			Rhyolite, granite porphyry, and related volcanics.
		Correspond for the greater part at least, to the Newer Volcanics of Upper White River district	Mainly andesite, basalt, and related volcanics; in places dominantly tuffaceous, the tuffs passing gradually into pure sandstones and conglomerates.
Mesozoic (may include some late Palæozoic members)	Probably Cretaceous or Jurassic	Probably correspond to Coast Range intrusives	Granitic rocks ranging in composition from granite to diorite, with associated porphyritic phases.
	Probably mainly about Jurassic, but may include older members	Older Volcanics of Upper White district	Andesite, diabase, basalt, and related volcanics, with associated tuffs and breccias.
Pre-Cambrian(?)		Yukon Group: Pelly gneisses	Granite gneiss.
		Yukon Group	Dominantly hornblende schist and gneiss, include also some sericitic gneiss and schist. Igneous origin.
		Yukon Group: Appears to correspond to Nasina series	Mica schist, mica gneiss, quartz-mica schist, quartz-mica gneiss, schistose and gneissoid quartzite, sheared conglomerate, phyllite, and limestone. Sedimentary origin.

Summary Descriptions of Formations

The oldest rocks exposed in Klotassin area are dominantly schistose or gneissoid in character and belong to the Yukon group which is thought to be entirely of Pre-Cambrian age*. These rocks are extensively developed in Klotassin area, and it was possible in the field to classify them into three main divisions. The most recent of these divisions is composed entirely of rocks that will here be termed granite gneisses, as they are evidently altered granitic rocks. The other members fall into two groups, one of igneous and

*Cairnes, D. D., "The Yukon-Alaska International Boundary," Geol. Surv., Canada, Mem. 67, 1914, pp. 38-44.

the other of sedimentary origin. The members of the sedimentary division are the oldest rocks in the district, and appear to correspond to McConnell's Nasina series[1]. They consist dominantly of mica schists and gneisses, quartz-mica schists and gneisses, schistose and gneissoid quartzites, phyllites, and bands of crystalline limestone. There is every transition from a rock composed almost entirely of quartz, to a definite mica schist. In places the mica or quartz-mica schists and gneisses are highly garnetiferous, the garnets being as much as one-quarter inch in diameter; in other places they exhibit considerable tourmaline which occurs in crystals as much as $1\frac{1}{2}$ inches in length. The older igneous division of the Yukon group is, dominantly at least, more recent than the sedimentary rocks, and includes mainly hornblende schists and gneisses, but some light grey to nearly white sericitic schists and gneisses also occur. All these sedimentary and igneous rocks, in addition to being intensely metamorphosed, are greatly distorted, folded, broken, and often even crumpled. The granite gneisses have the general appearance of dominantly coarsely textured, laminated granites, and distinctly cut the other members of the Yukon group. They evidently correspond to the Pelly gneisses which have been described by a number of writers[2].

More recent than the members of the Yukon group is a group of rocks corresponding to the Older Volcanics[3] of Upper White River district. These have only a relatively small development in Klotassin area, and are exposed mainly along the lower portion of the valley of Klotassin river. They are prevailingly dark coloured, greyish to greenish rocks, and include mainly andesites, basalts, and related types with their tuffaceous phases. These rocks are for the greater part quite massive, but in places they have a decidedly laminated structure. They are also in places much altered to epidote, and in places, for several hundred feet, are almost entirely changed to serpentine. Also they locally contain notable amounts of dolomite; and especially along Yukon river for a few miles below Selkirk, veins and irregular masses of this mineral nearly everywhere characterize these rocks. They are probably of early Mesozoic age, but may include older members.

The most extensively developed geological terrane in Klotassin area consists of granitic rocks ranging in composition from granite to diorite, with associated porphyritic phases. These rocks comprise a batholith which was explored for a length of about 50 miles, but neither end was reached. The width where mapped is in most places from 15 to 20 miles. This batholith much resembles the northern portion of the main Coast Range batholith, and may really be an outlying, subjacent portion of it. These granitic rocks cut the Older Volcanics and are probably of Jurassic or Cretaceous age.

Cutting the granitic intrusives there is developed a group of rocks corresponding apparently to the Newer Volcanics[4] of Upper White River district. These rocks include mainly andesitic and basaltic volcanics, and are everywhere massive and fresh appearing, and are prevailingly very susceptible to weathering agencies. In places they are so generally decomposed that

[1] McConnell, R. G., "Report on the Klondike gold fields," Geol. Surv., Canada, Ann. Rept., vol. XIV, 1901, pp. 12B-15B.

[2] McConnell, R. G., "Note on the so-called basal granite of Yukon Valley," *Am. Geologist*, vol. XXX, July, 1902, pp. 55-62.

[3] Cairnes, D. D., "Upper White River district, Yukon," Geol. Surv., Canada, Mem. 50, 1915, pp. 87-93.

[4] Idem., pp. 97-101.

it is very difficult to obtain a firm, solid, hand specimen. This group of rocks also includes a considerable proportion of pyroclastics, and the tuffs in places grade into true sediments. At one point beds of ordinary appearing shales, sandstones, and conglomerates are included with the tuffaceous members, and are intimately associated with them. These rocks are believed to be of Tertiary, probably early Tertiary, age.

More recent than all these older rocks, there occur, in places, dykes of rhyolite, granite porphyry, and related volcanics. These have no particular areal importance and appear to be genetically related to the granitic intrusives. Possibly they are a later phase of the same magma.

Overlying all the consolidated rock formations of the district, are the Pleistocene and Recent accumulations which include mainly gravel, sand, clay, silt, soil, muck, and ground-ice. These not only cover deeply all the main valley bottoms, but in addition, extend over considerable portions of the valley walls and upland.

Mineral Resources

The only minerals that are known to have been so far discovered in Klotassin area, in deposits of economic importance, are gold and wolframite (tungstate of iron and manganese (Fe, Mn)WO_4), both of which have been found only in placer form. For a number of years there has been a small gold production from Canadian creek, and last season a few hundred pounds of wolframite was also recovered there. Between 1911 and 1914, some prospecting and a small amount of mining were done in Britannia creek. Coffee creek has also been prospected to some extent. In addition, some of the tributaries of Selwyn river have been prospected, and for several years there has been a small annual output of gold from points on one of the tributaries of this stream a short distance east of the area mapped last summer. This includes practically all that was done in the way of mining or even of prospecting in Klotassin area and its immediate vicinity, until the spring of 1915 when gold was discovered on Rude creek. This discovery caused a stampede which resulted in the staking of all of Rude creek, as well as part of its parent stream, Dip creek, and several of their tributaries and subtributaries, including Trombley, Ray, Jens, Odin, Northey, Brown, Casino, Victor, Woodburn, and Bird creeks. Isaac creek and several of its tributaries, including Sunshine, Moonshine, Teddy, Idaho, and Alder creeks were also staked. A certain amount of prospecting has been done mainly on Rude creek and its tributaries, as well as along the upper portion of Dip creek, and on Isaac and Sunshine creeks. Actual mining has been done, however, only on Rude creek, and the production has been very small. It is expected that considerable prospecting will be performed this winter on the lower portion of Rude, and on Dip and Isaac creeks, as well as possibly in other places where the ground is sufficiently deep to be adapted to drifting.

Canadian Creek

Canadian creek is a tributary of Britannia creek, and joins it from the southwest about 5 miles above its mouth; Britannia creek joins the Yukon from the south about 50 miles below Selkirk. Discovery on Canadian creek is about 2 miles above its mouth, and was staked on April 21, 1911, by Jos. Britton and Chas. J. Brown. During the past summer only three claims, having a total length of about 1,500 feet, were being held on Canadian creek; these are located near the upper end of the creek, and are recorded as Nos. 71, 72, and 73 above Discovery. This ground was owned, when visited, by Daniel Mann, Nicola Hansen, and P. S. Larsen. Since then, it is understood, Larsen has sold his interest. Between the spring of 1911 and 1913, some prospecting was done at several points along the lower portion of Canadian creek, and from what can be learned as a result of this, it would appear that much of the ground might be mined at a profit, if the work were done to advantage. The indications are that this portion of the creek below the canyon is quite adapted to dredging. In the spring of 1913, Messrs. Mann, Hansen, and Larsen, moved to the upper portion of the creek, and have since then, each summer, mined the ground they now hold. From 1913 until the present, very little other work has been done on Canadian creek.

A small tributary stream about one-quarter mile long, joins Canadian creek on its right limit near its head, and about 8 miles above Britannia creek or 13 miles from the Yukon, measured along the valley bottom; and it is near the mouth of this small tributary, and well above timber-line, about 2,700 feet in elevation above the mouth of Britannia creek, that Mann and partners have performed most of their work. The depth to the bedrock channel along this upper part of Canadian creek is not known. Several shafts have been sunk, the deepest of which is 42 feet, but in only one of these was bedrock encountered, and there it was a sloping rim. The uppermost deposit at the workings of Mann and partners is a layer of muck about 3 feet thick, and directly underneath this are the pay gravels which have a thickness of 3 to 5 feet. Below these gravels, the various deposits down to bedrock, so far as they have been explored, do not pay to mine. These deposits in places are cemented by a reddish, iron-stained matrix, to form a 'hard-pan' or really quite a firm conglomeratic rock. The open-cut comprising the workings of Mann and partners is 75 feet wide, and is all in paying ground; thus the width of the pay gravels here is known to exceed 75 feet. In all, these partners have taken out between \$6,000 and \$7,000 in gold since the spring of 1913, of which between \$1,500 and \$2,000 was obtained during the past summer. They, however, did not commence to save the wolframite until last season, when only two of them were engaged in actual mining operations much of the time, the third being in ill health. Nevertheless, in a very short season, they recovered, in addition to the gold, between 500 and 600 pounds of high grade wolframite concentrate. Part of this has been shipped to the Canadian Munition Resources Commission, Ottawa, and was tested in the Ore Testing plant of the Department of Mines, and found to contain 64·42 per cent WO_3.

The mountains surrounding the head of Canadian creek are dominantly composed of Mesozoic granitic rocks. The small tributary stream near the mouth of which Messrs. Mann and partners are working, however, heads in a round hill about a mile in diameter, which is composed largely of pegmatitic and porphyritic rocks. The pegmatitic rocks are an extreme phase of the granitic terrane, while the porphyry, although possibly genetically related to the granitic intrusives is more recent, and has extensively invaded them. The whole pegmatite-porphyry hill is highly mineralized, chiefly with a yellowish iron ochre which is largely the decomposition product of iron-containing minerals, including pyrite, magnetite, and hematite. Some pyrite, magnetite, and hematite are still in evidence, but near the surface, they are for the greater part leached out leaving the iron ochre filling the various cavities which they formerly occupied. The central portion of this hill for a width of perhaps 1,500 feet is composed of a particularly quartzose pegmatitic rock, the quartz being associated mainly with hornblende, feldspars, and related minerals. This pegmatite is intersected in all directions by ramifying veins and stringers of quartz, so that the entire central mass of the hill is largely composed of quartz. It is evidently from this hill that the gold and wolframite now found in the gravels a few hundred feet below has been derived, although no single specimen could be found on the surface in which wolframite could be detected. Furthermore, three chipped samples A, B, and C were taken across about 900 feet of the central, best mineralized portion of this hill, each sample covering about one-third of the distance. These were assayed by the Mines Branch, Department of Mines, Ottawa, and were found to contain only slight amounts of gold and WO_3 (tungsten trioxide) as follows:

Sample	WO_3	Gold per ton.
A	Trace	40 cents
B	0·10 per cent	Trace
C	0·10 per cent	Trace

However, there is no evidence of glaciation in this vicinity, and, therefore, the gravels are all of local origin. Furthermore, the gold and wolframite occur dominantly at least in gravels near the surface, and the gold is notably very rough, the larger pieces including considerable quartz, and resembling fragments of rich gold-quartz veins rather than ordinary nuggets, indicating that the gold has been only slightly transported. It thus seems quite evident that the gold and wolframite were derived from this pegmatite-porphyry hill in which heads the small stream whose gravels are being mined only a few hundred feet below. Apparently a portion of this hill richer, in wolframite at least, than that part now exposed, has been broken down by stream and weathering processes to form the present placer deposits. As a result of the prospecting to date the wolframite appears to be practically limited in its occurrence to a portion of the basin at the head of Canadian creek, and is most plentiful in the vicinity of the present operations. Only a relatively small amount of this mineral has been carried any considerable distance downstream by Canadian creek. Gold prospects are believed, however, to have been found at a number of points along this upper portion of Canadian creek.

Next summer (1917), if the present plans of the owners are carried out, a production of 600 to 1,000 pounds of wolframite concentrates similar to that recovered during the past summer is to be expected, and also an amount of gold comparable to that obtained in the past season. If more men are employed and more equipment is installed, a greater production could be obtained, but owing to scarcity of water, the wolframite production at least probably could not be profitably increased to any very great extent. Thus in the ordinary course of events a production approximating only to that of last summer is to be expected for a number of years to come.

A fairly good trail continues up Britannia and Canadian creeks for 10 or 11 miles from Yukon river. Above this to the workings of Mann and partners, the trail is very difficult in summer, being practically impossible for pack-horses, particularly for a distance of about 2 miles through a constricted portion of the valley, locally known as the canyon, and for some distance above it, due to the occurrence of large granitic talus blocks which are strewn completely across the valley. In winter there would be no difficulty in sledding concentrates down Canadian and Britannia creeks to the Yukon, and in the spring these can be shipped on the river steamers which ply regularly up and down the Yukon all summer, and connect with outside points.

Rude Creek

Rude creek is a small stream whose main valley is about 6 miles long; it empties into Dip creek from the left (looking downstream), near its head, Dip creek above the confluence of these streams being comparable in size to Rude creek. The easiest way to reach Rude creek is by trail from the mouth of Isaac creek. Isaac creek joins Yukon river from the south about 43 miles below Selkirk. Two main trails have been constructed to Rude creek, and reach it near the head and near the mouth respectively, and at distances from the mouth of Isaac creek, of respectively about 14 and 16 miles.

The valley of Rude creek is decidedly V-shaped in cross-section, with walls rising rather abruptly to a height varying from a few hundred to over 1,000 feet, to meet the general upland. The hillsides constituting these valley walls, except near the extreme head of the creek, are nearly everywhere forested, mainly with small spruce; some poplars and shrubbery, however, also occur. Even the valley flat, which is in most places from 500 to 700 feet in width, is covered with a sparse growth of trees and shrubbery. The stream has no open flood-plain, but instead follows a narrow channel incised through the moss, muck, and underlying gravels.

The hills at the head of Rude creek, and down both sides of it, are composed entirely of granitic and porphyritic rocks. The granitic rocks are the Mesozoic intrusives which in places are porphyritic; these are cut by numerous dykes mainly of granite porphyry and rhyolite. Thus, since this vicinity has not been glaciated, the stream gravels are all of local origin, and consist almost entirely of these granitic and porphyritic rocks.

Discovery claim which is about 3 miles from the mouth of the creek, was staked on March 12, 1915, by Jens Rude and George Jensen, who worked on Rude creek a great part of the summers of 1915 and 1916. Bedrock along the upper part of the creek to below Discovery and in the central part of the valley is from 2 to 10 feet deep, in most places from 6 to 10 feet. At about No. 2 below Discovery, bedrock commences to get much deeper, but just how deep it is along the lower part of the creek has not been determined. Small deposits of terrace gravels occur in places along the valley walls, a few feet above the present valley bottom, and indicate positions Rude creek formerly held during the process of sinking its channel to its present level. When visited in June, about twenty-five men were engaged in prospecting and mining along Rude creek, but later in the season many of them left. It is expected, however, that a number of those owning claims with deep bedrock, will prospect their ground, by drifting, this winter. It is estimated that about $800 in gold was obtained from Discovery claim during the autumn of 1915, and during 1916, the owners claimed, while mining, to be recovering gold amounting to about wages, or a little better. In all probability less than $2,000 in gold has been obtained from Rude creek, nearly all of which came from Discovery. As a result of the work so far performed on this creek, the distribution of the gold both in the creek and terrace gravels, appears to be not only sparse, but very erratic.

Other Creeks

Some prospecting has been done on Isaac creek, and some of its tributaries, with, it is claimed, promising results. Also some work has been done on Dip and Victor creeks, and some of their tributaries, as well as on the tributaries of Rude creek, but the results are indefinite. Britannia creek on which Discovery was staked on April 18, 1911, by E. L. C. de la Pole and C. M. Printz, was prospected to quite an extent during 1911 and 1912, but no work has been done there since 1914. It is claimed that the results of the work there performed, indicate that the portion of the creek below the mouth of Canadian creek, about 5 miles in length, would pay well for dredging. The physical conditions, amount of water, etc., are, at least, adapted to dredging, and the bedrock in most places along the central part of the valley is only from 18 to 20 feet deep. It is thus hoped that this lower part of Britannia creek may be profitably dredged in the near future. Casino creek has been very slightly prospected, but one branch of this stream heads in the same pegmatite-porphyry hill as the small tributary of Canadian creek on which Mann and partners are working, and there also the same reddish gravels were noted. It is quite possible, therefore, that gold and wolframite may occur there the same as on Canadian creek, or even in greater amounts. Timber for fuel and constructional purposes is much more accessible than at the head of Canadian creek, so the working costs would be no more, and might prove somewhat less.

Summary and Conclusions

Klotassin area, as a whole, has been only slightly investigated and explored, and practically the only prospecting that has been done, has been for placer gold. Even in the case of placer gold, with the exception of Britannia and Canadian creeks, the prospecting has been largely confined to Rude creek and its close proximity. All around Rude creek, the geological formations are of Mesozoic or more recent age, and consist dominantly of granitic rocks which are extensively invaded by granite porphyry, rhyolites, and associated rocks. Such comparatively recent rocks, dominantly granitic, have not in Yukon or Alaska been so far found to give rise to placer deposits of any considerable importance. In the more southerly and southeasterly portions of Klotassin area, the geological formations consist largely of old, probably Pre-Cambrian metamorphic rocks which are to a great extent of sedimentary origin. These are extensively invaded by granitic, andesitic, basaltic, and other intrusives. Such a combination of geological formations is very favourable for the production of placer gold deposits, especially since there, as elsewhere in Klotassin area, no glaciation has taken place, and wherever valuable placer deposits have accumulated, there they probably still remain. It is particularly advisable, therefore, that the creeks of that portion of the area be carefully prospected, the smaller creeks being first tested, where the physical conditions are favourable, and where quick results can be obtained.

Scheelite and wolframite are reported to have been found in several portions of Klotassin area, but, so far, Canadian creek is the only locality where any tungsten mineral is actually known to have been discovered. The geological conditions are favourable for the occurrence of tungsten minerals throughout the granitic area, and especially around its periphery.

Saline Incrustations between Takhini and Canyon

Saline incrustations occur at a number of points throughout the wide valley occupied by Dezadeash river, and are particularly conspicuous along the Whitehorse-Kluane wagon road from mile post 30 to mile post 85 between Takhini and Canyon roadhouses. This saline material is white or nearly white in colour, and occurs mainly around the edges of many of the small lakes, ponds, or sloughs in the valley bottom, being left as a residue after the evaporation of the water. Along the wagon road, this material is most plentiful near 32-mile post, near 40-mile post, near Champagne Landing, and in the vicinity of Big Bend. Near 32-mile post or in the vicinity of the point where the Whitehorse-Kluane road branches off the main Whitehorse-Dawson road, the saline material occurs around a number of ponds or sloughs, but is only a surface blossom with practically no thickness. The deposits near 40-mile post, and in the vicinity of Champagne Landing, are of the same character, as are also others at various points between Champagne Landing and Big Bend, and for about 2 miles past Big Bend. The purest and most extensive deposits that were seen, occur just east of Big Bend which is about 13 miles west of Champagne Landing. There, for a distance of about one mile, a wide, nearly dry slough occurred, when visited, and the surface of the ground was covered with this whitish material, and, in places, quite pure white to colourless crystalline salts occurred in a layer $\frac{1}{8}$ to $\frac{1}{4}$ inch thick.

A typical sample of this saline incrustation was collected by the writer from a point near Champagne Landing in 1914. This was examined in the laboratory of the Mines Branch of the Department of Mines, Ottawa, and reported upon as follows:

"It proved on examination to be composed for the most part of a mixture of hydrated sulphates of sodium and calcium, and a small quantity of magnesium sulphate, with some insoluble argillaceous and organic matters. It is slightly ferruginous, and contains also a very small quantity of phosphates and chlorides."

It was thought this saline material might possibly contain important quantities of potash which is now greatly in demand; accordingly the writer was instructed to sample the various incrustations during the past summer. This was done early in August and twenty-three samples were taken. Six of these were tested for potash in the chemical laboratory of the Mines Branch of the Department of Mines, Ottawa, and found to contain potash as follows:

Sample No.	
No. 1	0·2 per cent K_2O
No. 5	0·3 "
No. 10	0·2 "
No. 14	0·2 "
No. 18	0·2 "
No. 23	0·2 "

It was thus decided that it would not be advisable to go to the expense of testing the remaining samples since those examined were found to contain potash in such slight amounts. This saline material would thus appear to be of no present economic value.

Lode Mining in the Windy Arm Portion, Conrad Mining District, Southern Yukon

During 1904 and 1905, a considerable number of mining claims were located in what is generally known as Windy Arm district, southern Yukon, most of which were acquired by Col. J. H. Conrad and the organizations which he controlled. In the spring of 1905 Col. Conrad commenced to develop these claims on quite an extensive scale, and continued operations until the summer of 1912 when he was obliged to close down, and the properties were taken over for money previously advanced, by the Mackenzie and Mann interests. From that time until the past summer (1916), no work was done on these properties. A number of additional claims constituting what has been generally known as the Dail and Fleming group, as well as the Ruby Silver, and possibly a few others, which were located about 1904 or 1905, are also still held, and on them a certain amount of development has also been done which, especially of late years, has been mainly in the form of the yearly representation work required by the government on all mining properties that are not crown granted.

Last spring (1916) the Lakinaw and Tagish Mines of Seattle, also known as the Harper syndicate, obtained a lease and bond on a number of the Conrad properties including the Montana, Mountain Hero, Vault, Venus No. 1, Venus No. 2, M and M, Joe Petty, Uranus No. 1, Uranus No. 2, Little Johnnie, Capella, and Black Jack. Mr. J. L. Harper of Seattle is general manager of this syndicate, and Mr. J. E. McFarland is superintendent of operations in southern Yukon. This syndicate commenced operations early in June, continued all summer, and proposed mining throughout the winter. The bulk of the work was done on the Venus No. 2 from which some small shipments of ore were made. Work was also commenced on the M and M and on the Montana.

Col. W. L. Stevenson, on behalf of the Alaska Corporation of Skagway, Alaska, or some of its subsidiary organizations, obtained from Mackenzie and Mann a working lease on the Big Thing and also commenced work last June (1916). Operations were continued all summer and it is expected that mining will be carried on throughout the winter.

Thus, as there has been practically no mining done in Windy Arm district since 1912, except a limited amount of yearly representation work on a few claims adjoining or near the Conrad properties, the commencement of operations again during the past summer has done much to encourage the lode mining industry of southern Yukon, and is regarded as a favourable omen for the near future. Accordingly, after completing work on Dublin gulch, and in Klotassin area, the writer spent a few days during the early part of October in Windy Arm district, and visited the properties there being developed. Both R. G. McConnell and the writer had examined the various Windy Arm mining properties during the early stage of their development, and have published brief reports* concerning them. Thus in this report which is to be regarded as merely of a preliminary nature, only those properties will be described on which work has recently been done. These include the Big Thing, Venus, M and M, and Montana, as well as certain claims of the Dail and Fleming group. Very little work has been done on any of the other properties of the district since the writer's early

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* McConnell, R. G., "Windy Arm District", Geol. Surv., Canada, Sum. Rept., 1905, pp. 26-32.

Cairnes, D. D., "A portion of Conrad and Whitehorse mining districts, Yukon", Geol. Surv., Canada, 1908.

"Windy arm", Geol. Surv., Canada, Sum. Rept., 1907, pp. 13, 14.

"Windy arm", Geol. Surv., Canada, Sum. Rept., 1908, p. 31.

reports were published. The ore deposits on all these properties are fissure veins which, with the exception of the Big Thing, intersect andesitic rocks; the Big Thing vein occurs in granitic rocks.

The information in this report concerning the values contained in the different veins has been derived from a number of sources. Since 1905, when mining operations were commenced in Windy Arm district, the writer has kept closely in touch with the development of the various properties, and has had access, through the courtesy of the owners, to all assay returns of samples taken from the different properties. Also these properties have been practically all carefully sampled at times for prospective purchasers, and in some cases the results of the assays of these samples have become known to the writer; and occasionally when reports were made by well known, and competent engineers, these reports have been afterwards loaned to the writer. In addition, much valuable information has been obtained from the government assay office in Whitehorse, where hundreds of samples of Windy Arm ores have been tested. Furthermore, in 1912, Mr. T. A. MacLean sampled a number of the Windy Arm properties for the Mines Branch of the Department of Mines, Ottawa, and the results of his work have been published*.

Location and Accessibility

The area that is in a general way known as Windy Arm district lies for the greater part at least in the southern portion of Conrad mining district of southern Yukon; but, as the upper end of Windy Arm reaches south of the 60th parallel, the Yukon-British Columbia boundary, Windy Arm district, might be considered to extend into northern British Columbia. The properties described in this report, however, are all in Yukon, and all lie within an area bounded on the south by the 60th parallel, on the west by lake Bennett, on the north by Nares lake and Tagish lake, and on the east by Windy arm, and are thus included between longitudes 134° 40′ and 134° 50′ and between latitudes 60° 00′ and 60° 10′.

Caribou**, a point on the White Pass and Yukon railway, serves as a distributing centre for Windy Arm district. This point is 68 miles by rail from Skagway which is itself situated at the head of Lynn canal. From Skagway, coast steamers make regular and frequent trips to Vancouver and Seattle, distances respectively of 867 and 1,000 miles. From Caribou a wagon road has been built to the Big Thing, a distance of about 6 miles. Another wagon road has been built from Caribou to Conrad, a deserted village on the west shore of Windy Arm. The distances from Caribou to Conrad and the Venus mine, by water, are $11\frac{1}{2}$ and $15\frac{1}{2}$ miles, respectively; and practically all freight to and from points along Windy Arm at present, goes by water. There is a good grade for a railway from Caribou along the shores of Nares lake, Tagish lake, and Windy Arm, whenever it is found advisable to build such a road. Thus the Windy Arm properties are all quite readily accessible, and practically all except the Big Thing, are situated at distances of from $\frac{1}{2}$ to 4 miles from Windy Arm, and at elevations of from 1,200 to 3,600 feet above it. Thus all ore to be conveyed to the water's edge for shipment or treatment, has a downhill haul, for which aerial tramways have been or can readily be constructed.

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*MacLean, T. A., "Lode mining in Yukon", Dept. of Mines, Mines Branch, 1914, pp. 188-201.

**The name of the post-office at Caribou station is Carcross.

Big Thing

The Big Thing is located about $5\frac{1}{2}$ miles almost due south from Caribou whence a good wagon road has been built to the property. It is also situated above timber-line, and near the summit of a gently contoured hill known as Sugar Loaf hill. The upper workings on the property have an elevation of about 3,500 feet above lake Bennett which is about 2,160 feet above sea-level.

The Big Thing was owned for a number of years by one of the Col. Conrad organizations which did the initial development on the property in 1905. In 1912 the Big Thing was taken over for money advanced, by representatives of Mackenzie and Mann who still own the property. Last June Col. W. L. Stevenson, managing director of the Alaska Corporation of Skagway, Alaska, commenced to re-open the property on behalf of the Alaska Corporation or one of its subsidiary organizations, he, it is understood, having obtained a working lease from Mackenzie and Mann.

Development

Development work on the Big Thing began in 1905, and continued for the greater part of the time from then until June, 1912. During July and August, 1912, some contract work was also performed. From that time, however, the property was not again worked until June, 1916.

During the years 1905 to 1912, a considerable amount of work was done on this property, much of which, however, is now of little or no value. An incline shaft was sunk 450 feet, which follows the vein down from the surface for about 400 feet; in this distance one or two faults of slight displacement were encountered. At a depth of 400 feet, measured down the incline shaft, another fault was struck, but the shaft was nevertheless continued for 50 feet or more at practically the same inclination, although the vein did not again appear. Four levels were driven from the shaft, but the vein has been most developed on the third and fourth. The first level comprises about 120 feet of drifting, the second, about 50 feet, the third or 300-foot level, about 185 feet, and the fourth or 400-foot level, over 700 feet of drifting. Some stoping was also done, two winzes having an aggregate depth of 40 feet were sunk, and various irregular workings were excavated.

An adit or so-called tunnel, intended to crosscut the vein at depth, was driven 2,320 feet, and from this adit, several irregular prospecting crosscuts as well as two long, irregular upraises were driven. One of the upraises was considerably misdirected, and did not encounter the vein at all. The other, driven from near the end of the adit, finally tapped the vein at the 400-foot level in the upper workings, and near the point where the shaft crosses this level. In the adit, a vein about 18 or 20 inches in thickness is crosscut, which has a strike and dip similar to the main vein above, but it is not at all certain they are the same vein.

During the past summer most of the old workings were again opened up, and the vein was further developed on and immediately below the 400-foot level. A branch upraise was also driven off one of the upraises from the adit; this branch upraise was started from near the top of the old upraise to the 400-foot level, and in it the vein was again encountered, this time a few feet below this level.

Vein

The ore deposit on the Big Thing is a fissure vein which intersects granitic rocks of Jurassic or Cretaceous age. It strikes approximately north 55 degrees east (astronomic)*, and dips to the northwest at angles generally between 25 degrees and 35 degrees. It is usually from 2 to 8 feet in thickness, although in places it is as much as 12 feet thick; and it is composed dominantly of quartz which is fairly well mineralized chiefly with pyrite, but also contains some disseminated arsenopyrite, as well as occasional particles of chalcopyrite, galena, and stibnite. The vein is chiefly of value for its gold content, but also contains some silver.

To the east of the shaft, the formation is in places much disturbed and broken; and great difficulty has been experienced in following the vein there, due to its being repeatedly faulted in various directions. To the west of the shaft, however, the vein where exposed in the different levels is relatively quite regular, and although two main faults are in evidence in the 400-foot level, they do not materially interfere with mining operations. The displacement of the main fault first encountered at the 400-foot level decreases toward the west, and practically disappears a short distance from the shaft. Thus in this direction it has been possible to extend the development work on the vein below the 400-foot level.

On the 400-foot level to the west of the shaft, the vein is from $2\frac{1}{2}$ to 8 feet in thickness, and is quite regular and well mineralized. In fact it is there very promising in appearance, quite as much so as in the upper levels. The shaft and levels, up to the time when visited early in October, had practically blocked out about 75,000 tons of ore, excluding the much faulted portions of the vein to the east of the shaft, and allowing for small stopes from which the ore had been mined and shipped. This 75,000 tons is what might be considered as ore in sight, that could be mined without difficulty. The total 'probable ore' on the property would be several times this amount, as, particularly to the west of the shaft, the vein has every appearance of persisting to important distances both vertically and horizontally.

It is not known exactly what amounts of gold and silver this 75,000 tons will carry, but nevertheless considerable information concerning these values is available. This includes the results of the assays of a great number of samples taken both by the owners and prospective purchasers, these results having become known to the writer; also much valuable information concerning the values in this vein has been obtained at the government assay office in Whitehorse, where many samples from this deposit have been tested. Assays of $30 to $40 per ton in gold and silver are known to have been obtained, and much higher results have been reported. The writer has estimated as a result of all the information available, checked by personal observation during a number of visits, that the 75,000 tons of ore that is blocked out, will average in the neighbourhood of $15 per ton in gold and silver, or possibly slightly more. One estimate by the former management placed the average value of the entire vein so far explored, as low as $12 per ton in gold and silver. By a study of the mineralization of the vein, and with careful selective mining, no doubt important shipments can be obtained that will average over $20 and possibly between $25 and $30 per ton. The vein affords, however, an ideal concentrating ore, and for the economical and profitable working of this deposit, it will be necessary to concentrate before shipping.

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* The magnetic declination in Windy Arm district is generally about 32° 30′ east.

Equipment

A power plant has been installed at the mouth of McDonald creek, on the shore of lake Bennett, and within a few feet of the White Pass and Yukon Railway line. The plant includes a 100-horsepower boiler, and an electric generator which supplies power to the mine over a transmission line $4\frac{1}{4}$ miles long. At the mine considerable equipment has been installed, including a hoisting engine, a 40-horsepower motor, a 100-horsepower motor, 3-drill compressor, an 8-drill compressor, and a blacksmith and repair shop. Comfortable buildings have been erected, and a telephone line connects the mine with Caribou, and also with the power plant.

Summary and Conclusions

In the past the Big Thing vein has been mined, in most cases, none too economically, and the ore has then been hauled in wagons to Caribou, and shipped from there by rail and boat to coast points for treatment. The cost of operating in this way prohibits the development of the ore-body, at least on an extensive scale, as only a limited amount of the ore is rich enough to cover these expenses. To develop the property at all extensively, a concentrator will have to be built at some point near the mine workings, either actually at the mine, or on lake Bennett along the railway.

Montana

The Montana is one of the most important of the original Conrad properties, and is one of those at present under bond to the Harper Syndicate of Seattle. It is located on a bleak mountain side, high above timber-line, and about 3 miles from the Big Thing in a direction somewhat east of south; it is also about $2\frac{1}{2}$ miles from the shore of Windy Arm at the nearest point, and about 3,700 feet above it.

Development

A drift has been driven along the vein for a distance of about 700 feet. An incline shaft has also been sunk which follows the vein for a part of its depth, but departs from it as the vein changes its dip. A short crosscut has been run from the bottom of the shaft to intersect the vein at that depth. Also on the adjoining Mountain Hero claim, a crosscut adit was run about 300 feet, and a 65-foot upraise was driven from the end of the adit, in the hope of cross-cutting the Montana vein at depth, but no important vein was encountered in the adit or upraise. This work was all done during the period of Col. Conrad's control. The work of the Harper syndicate up to the time of the writer's visit in October had been confined largely to digging the ice from the shaft and other workings, and the ice had not yet been completely removed. When this was accomplished, it was proposed to commence development work.

Vein

The Montana vein strikes north 43 degrees west (magnetic) and dips to the southwest at angles ranging from 10 degrees to 30 degrees. It occurs in a fissure intersecting greyish green to dark greenish, volcanic rocks which are dominantly andesites, basalts, and related types, and are thought to be of Cretaceous or Jurassic age. The vein ranges in thickness in most places from 2 to 5 feet, and is composed mainly of quartz with which is associated galena, pyrite, arsenopyrite, pyrargyrite, argentite, tetrahedrite, native silver, and lead carbonate. The principal values are in silver, but the pyritic portions also contain some gold. In places, the vein matter, especially adjoining the walls for thicknesses of 8 to 18 inches, is very highly impregnated with silver minerals, and assays $80 to $90 per ton; this ore could be shipped without sorting. The rest of the vein is of much lower grade, and requires concentration. On the whole, this is considered to be one of the most important veins in the Windy Arm district.

Equipment

A Riblet double-cable aerial tramway extends from Conrad on Windy arm, to the mouth of the crosscut on the Mountain Hero claim which adjoins the Montana. The tramway is 18,697 feet long, and has its upper terminal 3,464 feet above the lower. This tramway is of little service in its present position, but could be shifted so as to be of benefit to the Montana, or other claims in the vicinity. A 50-horsepower compressor plant with gasoline engine has been installed near the mouth of the Mountain Hero adit. The equipment also includes machine drills, a blacksmith shop, etc.; in addition comfortable stone buildings for offices, as well as mess and bunk-houses, have been erected on the property.

M and M

The M and M is also one of the original Conrad claims which is at present under option to the Harper syndicate. The vein outcrops on the left bank of Pooly canyon near the top of the hill, and has been traced about 400 feet or possibly farther. It strikes nearly due north and south, and dips to the west at an angle of about 15 degrees. The vein also occurs in a fissure in andesitic rock, and is in most places from 6 to 12 inches in thickness. It is composed mainly of quartz with which occurs pyrargyrite (ruby silver), stephanite (brittle silver), freibergite, tetrahedrite (grey copper), and blue and green copper carbonates. This deposit is especially rich in the high grade silver minerals. A shipment of 5 or 6 tons of ore from the M and M, made by Conrad, is reported to have given returns of $165 per ton in gold and silver, the values being mainly in silver. Ore from this deposit can be hand-sorted to carry $100 to $200 per ton, but parts of the vein do not run over $20 or perhaps less.

A comparatively slight amount of work has been done on this property, including one main drift 90 feet long, and some shorter ones 12 to 15 feet driven on the vein, and also some surface cuts and trenches.

Venus

On the Venus No. 1, only a small amount of work has been performed, but on the Venus No. 2, considerable exploratory work as well as an important amount of actual mining have been done. Thus locally the name Venus is generally used in referring to the Venus No. 2, and, unless otherwise mentioned, it will be here used with that meaning. The Venus No. 2 and Venus No. 1 adjoin, and the vein developed on each property is usually considered to be the same deposit.

The Venus is one of the most extensively developed of the original Conrad properties, but has, like the others, been closed for some years. It is also one of the properties at present under bond to the Harper syndicate, and is the one which they mainly worked during the past summer. Actual mining operations commenced on June 8, 1916, and some small shipments of ore were made.

Development

On the Venus No. 1, a shaft 52 feet deep has been sunk on the vein, and from the bottom of the shaft, drifts have been run about 50 feet in each direction. This comprises practically all the development work on the property.

On the Venus No. 2, two adits or so-called crosscut tunnels have been driven, which tap the vein at different depths. The upper adit is about 80 feet long, and encounters the vein at a depth of 75 feet below the surface. The lower adit is about 600 feet long, and cuts the vein at a depth of 263 feet below the level of the upper adit, measured along the slope of the vein. From the upper adit, drifts have been run distances of 108 and 88 feet to the south and north respectively, which comprise the upper level of the mine workings. Some stopes also have been excavated from this level. From the lower adit, drifts have also been driven 583 and 622 feet to the south and north respectively. Several raises have been driven from this lower level, and stopes have been excavated, one of the raises running to the surface a distance of 213 feet measured along the vein. Two winzes have been sunk from the north and south drifts of the lower level which are said to be 235 and 400 feet deep respectively. Some drifting has also been done from these winzes which, however, were full of water when visited. This work, as just outlined, was mostly done for Col. Conrad, but it includes also that performed by the Harper syndicate up to the time of the writer's visit early in October last (1916).

Vein

The Venus vein occurs in a fissure, in places of a compound nature, which traverses andesitic rocks believed to be of Cretaceous or Jurassic age. These rocks are in places decidedly tuffaceous in character, and, especially in the vicinity of the Venus, are quite reddish in colour, due to the presence of iron oxide. The vein strikes about north 10 degrees east (astronomic), has a dip to the west, into the hill, ranging from nearly flat to approaching 60 degrees. The dip in the workings on the Venus property, however, is in most places between 25 and 30 degrees. The vein itself has been produced mainly by direct deposition in open crevices, as is indicated by the pronounced banding and comb structures, but it is also partly the result of replacement of the wall rock. The fissure containing the vein is in most places of a compound nature, i.e. it is really several close parallel fissures, between which is more or less crushed and broken rock. The vein as a whole is thus usually well defined by two main fault planes from a few inches to 8 or 9 feet apart. Between these is the vein material, and more or less replaced wall rock, occurring in bands parallel to the walls, or in irregular fragments or blocks. The actual ore material ranges from an inch to 7 feet in thickness, but is, in most places where exposed in the underground workings, from 2½ to 3 feet thick. At the ends of both of the lower drifts it is exceptionally thin, however. At the end of the south drift it pinches to less than an inch, and in the north drift for some distance before the end is reached it is only from 2 to 6 inches thick. These pinches do not probably indicate the approaching ends of the vein, for the reason that on the surface the vein is strong and well mineralized for a considerable distance past the ends of the drifts.

The vein minerals include mainly quartz, galena, pyrite, and arsenopyrite, but some jamesonite, yukonite*, chalcopyrite, and copper glance also occur, as well as the oxidation products, lead carbonate, and green and blue copper stains. The values in the veins are mainly in silver which occurs dominantly associated with the galena. The galena is generally finely textured and markedly cubical but in places it is fibrous, and has been mistaken for stibnite. Important amounts of gold also occur, which appears to be for the greater part associated with the arsenopyrite. The gold and silver contents vary greatly. A few samples have been obtained which ran $200 or over per ton in gold and silver, but the information available, including the assay returns of a great many samples, taken both by the operators and by prospective purchasers, the results of which have become known to the writer, show the vein in most places to carry from less than one ounce to over 100 ounces in silver per ton, and from a trace to about $100 in gold; the gold, however, seldom exceeds $50, and is generally under $25. Where the ore is unaltered, it contains up to 15 per cent lead, and from a trace to nearly 1 per cent copper. The ore in the higher grade shoots averages from $30 to $50 per ton in all values. Much of the vein, however, is very low grade, running from almost nothing to about $20 per ton. During the past summer, up to the time when visited early in October, 1916, about 300 tons of sorted ore had been shipped to Anyox, B.C.; this averaged about $70 per ton. It is claimed that Conrad mined about 6,000 tons of ore from the Venus, part of which was shipped to the smelters at Ladysmith and Tacoma, the remainder being treated in the Venus mill.

Equipment

A concentrating mill has been built on the shore of Windy arm immediately below the mouth of the lower adit, and was completed during the summer of 1908. It was said to have a capacity of 100 tons a day. The equipment includes a 100-horsepower boiler and a 75-horsepower engine, for generating the motive power, also a partly installed hydraulic plant to obtain power from Pooly canyon. The concentrating equipment embraces a grizzly, Blake crusher, trommels, high-speed rolls, a Huntingdon mill, jigs, four Callow screens, six Callow settling tanks, three Wilfley tables, and two Frue vanners. The mill was run only a short time when losses in the slimes were found to be very high; as a result, it was closed, and has not since been in operation.

An aerial two-bucket tramway 1,525 feet long, connects the lower adit with the mill—the upper terminal being 958 feet above the lower.

The equipment also includes an engine and compressor for operating machine drills, a hoist, machine drills, ore cars, blacksmith shop, etc. Comfortable bunk- and cook-houses have also been erected on the beach near the workings.

Freight Charges

All ore at present shipped from the Venus to outside points has to be sacked owing to water transportation facilities between the mine and the

*A hydrated arsenate of calcium and iron. *See* Johnston, Robert, A. A., "A list of Canadian mineral occurrences", Geol. Surv., Canada, Mem. 74, 1915, p. 240.

railway at Caribou, and also because of the limited reloading equipment at Caribou. The summer freight rate on this sacked ore from the Venus to the smelter at Anyox, B.C., during the past summer (1916) was $5.50 per ton.

Summary and Conclusions

The Venus is being operated at present under a number of disadvantages. The ore has to be sorted on the property and shipped to coast smelters for treatment. If the ore could be successfully concentrated before shipping, a great economy would be effected, and more of the vein could be profitably mined. The ore, however, contains brittle and even oxidized minerals, to such an extent that any attempt at water concentration will result in heavy losses in slimes, unless a cyanidation plant be installed for treating the tailings, and this would be feasible only with a large tonnage blocked out. Furthermore, at present, all ore being shipped has to be sacked. If arrangements could be made for shipping the ore without sacking it, a considerable saving would result, but this extra cost seems difficult to avoid.

It is difficult to estimate at all closely the ore blocked out that can be profitably mined under existing conditions. There is, however, considerable information available on this point including the returns for various ore shipments, and the assays of a great number of samples taken both by the operators and prospective purchasers, the results of which have become known to the writer. This has all been checked and supplemented by personal observations by the writer. From all the information available, there would seem to be about 20,000 tons practically in sight. If the ore could be concentrated with a satisfactory saving, and at a reasonable cost, this ore estimate would be increased three or four times. Also, as the vein has the appearance on the surface of being persistent, the amount of 'probable ore' on the Venus No. 1 and Venus No. 2, is several times the 'ore in sight'.

Dail and Fleming Group

A number of claims, that since 1905 have been generally known as the Dail and Fleming group, are located along the west side of Windy arm, immediately to the south of the Venus. These claims include the Venus Extension, Red Deer, Humper No. 1, Humper No. 2, Nipper No. 2, and the Beach, all of which with the exception of the Nipper No. 2, were staked in 1904 by George Dail and I. E. Fleming. Later Dail and Fleming found that there was vacant ground between the Venus Extension and the Beach and in 1905 they staked the Nipper No. 2 to cover it. An interest in the group was later acquired by John Miller. In 1906 these claims were bonded to the Anglo-American Consolidated Company of Seattle for two years. That company sunk the Venus Extension shaft, and drove drifts from it, and also did the work on the Nipper No. 2. At the expiration of the bond, terms could not again be agreed upon, and the property reverted to the owners. They immediately gave a three years' option to Col. Conrad who did some work and placed considerable machinery on the ground for driving a 500-foot crosscut adit. He, however, failed to do the work as agreed, and in 1910 forfeited his option and machinery. Since that time practically the only development performed is the annual assessment work required by the government, which has been done by the owners.

Recently the ownership has changed. The claims have been divided into two groups, the Venus Extension group, and the Humper group. The Venus Extension group includes the Venus Extension, Red Deer, and

Humper No. 1, and is owned by I. E. Fleming and John Miller. The Humper group, embracing the Humper No. 2, Nipper No. 2, and the Beach, is reported to be owned by John Miller and Mrs. M. Watson.

Development

The bulk of the development work on these claims has been performed on the Venus Extension claim which adjoins the Venus No. 2; but the following comprises practically all the work that has been done on the entire group.

On the Venus Extension and near the northern end of the claim, an incline shaft has been sunk on the vein for 120 feet, and at a depth of about 40 feet, drifts having an aggregate length of about 45 feet have been run in each direction. About 200 feet from the south end of the claim an open-cut has been run in about 30 feet, and has exposed the vein below the loose overburden. Near the south end of the claim, a crosscut adit, or so-called tunnel, was driven diagonally 55 feet to the vein, and thence continued as a drift along the vein 150 feet farther, making a total length of 205 feet. Some short cross drifts have also been driven from the main drift and a few small surface cuts have been dug.

On the Beach and Red Deer claims, a small amount of surface work only has been done.

On the Nipper No. 2 a number of pits and cuts have been excavated in the hope of finding the extension of the Venus vein. About 85 feet from the south side of the claim, a crosscut was driven 45 feet and a winze was sunk 30 feet, from the bottom of which a short drift was run on a narrow, apparently low grade vein 6 to 8 inches in thickness.

On the Humper No. 1, and near the south end of the claim a pit was sunk 16 feet on the Humper vein. About 300 feet southwest of this pit, and near the northern end of the Humper No. 2, an open-cut has been run 20 feet into the same vein and from the bottom of the open-cut, a winze has been sunk about 16 feet. From the open-cut, about 40 feet of drifting has been done and from the drifts stopes have been raised to the surface.

Veins

Three principal veins have been found to occur on these claims. These are known as the Venus, Humper, and Red Deer veins respectively.

The Venus vein is the same as the one developed on the Venus property, and has been traced from the Venus No. 2 almost entirely across the Venus Extension, but so far as is known has not been found as yet on the adjoining property to the south, the Nipper No. 2. What is known concerning this vein on the Venus Extension, has been mainly derived from the shaft and main adit or drift. The vein possesses the same main characteristics as that on the Venus No. 2, and ranges in thickness from a few inches to 4 feet, being generally from 18 to 30 inches. On the Venus Extension, however, the vein is intensely leached and oxidized. In the drift or adit, practically no sulphides occur for the first 130 feet, after which some pyrite, arsenopyrite, and galena appear. The considerable degree of oxidation is here partly accounted for by the fact that the drift has a diagonal course into the hill and thus gains depth very slowly. The attitude of the vein as exposed in the drift is undulating, but in a general way is nearly flat. The vein in the drift also ranges in thickness from 6 inches or less, to about 30 inches, being in most places under 20 inches. The gold content is in most places from $5 to

$25, but occasional assays have been obtained running to about $100. The average silver content is believed to be generally under 10 ounces per ton. In the shaft the vein is also greatly oxidized, but pyrite, arsenopyrite, and galena occur; also yukonite, lead carbonate, and some bright red and yellow minerals which have proved to be realgar (arsenic monosulphide, AsS) and orpiment (arsenic trisulphide As_2S_3) respectively. The vein in the shaft ranges in dip from 15 to 35 degrees, and has a thickness in most places of 10 to 36 inches. The gold and silver content is about the same as in the drift, being slightly higher if anything. The gold ranges from about $2 to $50, but is generally under $25; and is believed to average more nearly $15 per ton. The silver runs from less than an ounce to over 100 ounces, but, except for occasional rich spots, probably does not average over 5 to 10 ounces per ton. The lead value ranges from about $1 to $30, averaging in unleached portions of the ore, between $4 and $5 per ton. The total values in gold, silver, and lead run from about $5 to over $100, but the average for this vein on the Venus Extension is rather low. Important amounts of ore occur, however, that could be mined, hand sorted, and treated at a profit. An attempt should be made to open up this vein at a depth below the oxidized and leached zone, the best method for doing so, being probably by a crosscut adit and drifts.

The Humper vein also occurs in a fissure traversing andesitic rocks of probably Mesozoic age, and has been traced for about 600 feet. The strike varies from east and west to about north 60 degrees east (astronomic), and the dip ranges from 35 degrees to 65 degrees to the north and northeast. The thickness of the vein is from 10 to 24 inches in most places where explored. The gangue of the vein is chiefly quartz with which is associated argentite, pyrargyrite (ruby silver), stephanite (brittle silver), galena, pyrite, and some native silver. Parts of the vein, at least, are very rich in silver, but the average gold and silver content is not known at all closely.

The Red Deer vein is also in a fissure in the Mesozoic andesitic rocks; it strikes about north 30 degrees east (astronomic), and dips to the northwest at an angle of about 50 degrees. It is, where exposed, also from a few inches up to about 3 feet in thickness, and is composed mainly of quartz which carries pyrite, galena, and various high grade silver minerals. This vein on the Red Deer claim is supposed to be the extension of the high grade vein on the Ruby Silver, a claim held by private parties, which has not been worked for a number of years. Very little is known concerning the Red Deer vein, as it has been so slightly developed.

Equipment

The machinery placed on the property by Col. Conrad during the term of his option is still there. This includes a boiler, compressor, two small air receivers, piping, rails, mine cars, blacksmith tools, etc. Several log cabins have been built on these claims, most of which are on the shore of Windy Arm.

Summary and Conclusions

The veins on these claims with the exception of the Venus vein, have been very slightly explored, and mainly only the upper oxidized and leached portion of the Venus vein has been developed. Further, when attempts were made a few years ago to develop the ore deposits on these claims, the freight rates charged by the White Pass and Yukon railway and boat lines were much higher than at present. There is good reason to believe that under existing conditions, portions of the Venus and Humper veins, and possibly the Red Deer vein, under good management, and with hand sorting, would pay to mine and treat. If a concentrator were built on Windy arm, or the one already there were remodelled to successfully treat these ores, it is believed that an important tonnage and revenue would result.

1917

Introductory Note

The following note on field work in Yukon Territory is given by W. McInnes, Directing Geologist, in the Summary Report for 1917, part A, page 1:

"W. E. Cockfield spent the field season of 1917 exploring portions of Sixtymile and Ladue River Valleys, Yukon Territory. A short report by Mr. Cockfield covering this work has been published in Part B of the Summary Report for 1917. Placer gold was found in the gravels of Sixtymile district, three years before the Klondike discovery, and the district is by no means yet exhausted. The sulphide of mercury, cinnabar, is associated with gold in the gravels."

The preliminary report by W. E. Cockfield, which followed in Part B of the Summary Report for 1917, and dealt with his exploration on Sixtymile and Ladue Rivers, is not reprinted, as the information it contains was later published in Memoir No. 123, of which a supply is available.

1918

Introductory Note

The following note by W. McInnes, Directing Geologist, from the Summary Report for 1918, part A, page 1, relates to field work in Yukon Territory:

"W. E. Cockfield spent the greater part of the field season of 1918 examining the mineral resources of Mayo area, Upper Stewart River district, Yukon Territory. This area is attracting attention since it is the only region in central Yukon in which, as yet, promising lode deposits have been located in considerable numbers. The lodes carry values in silver and lead, gold and silver, or tungsten. Cockfield also made a preliminary examination of the high grade silver-lead deposits of Spotted Fawn Gulch, Twelvemile area, Yukon. Reports by Cockfield on these two areas have been published in Part B of the Summary Report for 1918."

MAYO AREA

by W. E. Cockfield

Introduction

The greater part of the field season of 1918 was spent in an examination of the mineral resources of Mayo area, upper Stewart River district. During the course of this work particular attention was paid to the deposits of tungsten on Dublin gulch and the silver-lead deposits on Lookout mountain (Mt. Haldane). Towards the close of the summer a visit was made to the silver-lead deposits on Spotted Fawn gulch, a tributary to Little Twelvemile creek. When on the way out, learning through Mr. Wm. Sime of the Territorial Assay Office, of certain platinum deposits on Burwash creek it was decided to visit these, as the situation with regard to this mineral had become acute, owing to the supply from the Ural mountains in Russia being cut off. The information gained as the result of this visit has been furnished to J. J. O'Neill and is contained in his report dealing with the platinum situation in Canada.

The following report is intended to embody only the results obtained in the field, and must be considered as preliminary. Discussions as to the genesis of certain ore-bodies have been purposely omitted for the sake of brevity.

Mayo area for the past few years has been attracting more and more attention from a mining standpoint, as it is the only district in central Yukon, in which promising lode deposits have been located in considerable numbers. Consequently the writer received instructions to visit this district and examine the various deposits. No attempt was made to map the areal geology, as a reconnaissance map by Keele* has been published on which the general geology is shown.

Throughout the course of the work the miners and other inhabitants of the district assisted in every way possible. For the many favours and courtesies received the writer wishes to express his hearty thanks. Particular mention should be made of Corporal Waters of the Royal Northwest

* Keele, J., "Upper Stewart River region", Geol. Surv., Canada, Ann. Rept., vol. XVI, 1905, pt. C.

Mounted Police, who stored parts of the outfit; Captain Telford of the Royal Northwest Mounted Police, who kindly assisted with the preparations for the trip; Mr. Alex. Nichol who placed a building at the disposal of the party for the storage of supplies; and Mr. Robert Fisher who did much of the panning in connexion with the scheelite deposits.

E. W. Beltz was attached to the party as assistant and performed his duties in a very capable and satisfactory manner.

Location and Accessibility

Mayo area takes its name from the town of Mayo, which is situated on upper Stewart river 180 miles above its mouth. The name has been somewhat arbitrarily applied to the part of the Duncan mining district for which the town acts as a base, and the area extends north from Stewart river to include Haggart creek and Dublin gulch, east to the foot of McQuesten lake and Duncan creek, and west to include Highet and Johnson creeks.

All parts of the area are readily accessible. Stewart river opens early in May and remains open, usually, until after the middle of October. During the open season of navigation, the White Pass and Yukon Route maintains a regular passenger and freight service to Mayo from Dawson. In winter there is a stage service between Dawson and Mayo, trips being made about once in three weeks. From Mayo a good wagon road has been constructed to Minto Bridge, a village lying 10 miles north of Mayo, and from this point roads radiate to all the important creeks.

The rates charged for freight vary greatly. From Dawson to Mayo the freight rate is $40 per ton. From Mayo to Highet creek the rate is 2 cents per pound, the distance being 22 miles, and from Mayo to Dublin gulch the rate is 10 cents per pound. Return freight is frequently carried at half the above rates, and winter rates are usually less than half the summer rates. Ore shipments are usually handled by contract, so that large shipments may be made from points well inland from Mayo, to smelters on the Pacific coast, for $45 to $50 per ton.

Previous Work

During the summer of 1900 McConnell[1] made a geological examination of Stewart valley from Frazer falls down to Yukon river, and in 1904 and 1905 Keele[2] made a geological reconnaissance. His reports and map contain much valuable information concerning the district. In 1913 MacLean[3] sampled the lode deposits on behalf of the Mines Branch. In 1915 Cairnes[4] made a preliminary examination of the district, and returned in 1916 to spend a week investigating the placer deposits of tungsten minerals on Dublin gulch.

Topography and General Geology

Mayo area lies entirely within the physiographic unit known as Yukon plateau and is situated well towards the eastern flank of the province. It is characterized by being subdivided into isolated mountain groups separated

[1]McConnell, R. G., Geol. Surv., Canada, Ann. Rept., vol. XIII, 1900, pp. 39A-43A.

[2]Keele, J., Geol. Surv., Canada., Sum. Rept., 1904, pp. 18A-42A, "Upper Stewart River region", Geol. Surv., Canada, Ann. Rept., vol. XVI, 1905, pt. C.

[3]MacLean, T. A., "Lode mining in Yukon", Mines Branch, Dept. of Mines, Canada, 1914, pp. 127-159.

[4]Cairnes, D. D., Geol. Surv., Canada, Sum. Rept., 1915, pp. 10-34; 1916, pp. 12-20.

by broad, flat-bottomed valleys. The inter-stream areas are prevailingly flat-topped and stand at general elevations of from 4,500 to 5,000 feet, the elevation increasing slightly towards the east. These upland surfaces form parts of a former plain-like surface, which has been uplifted and dissected. Occasional peaks rise above the general level of the plateau surface and probably represent masses that were not reduced at the time of planation.

The district has been intensely glaciated, all but the upland having been covered by ice which rounded, smoothed, and scoured the valley walls, thus giving to the depressions typical U-shaped cross sections. The valleys are floored with glacial accumulations, through which the streams have cut, forming terraces, along which kettle holes are exceedingly numerous.

As a result of glaciation the drainage was disorganized and many striking changes have been forced upon the river systems of the area. From an economic standpoint, the most important of these changes are those which resulted in the formation of the canyons through which nearly all the smaller creeks enter the main streams. The formation of the canyons has probably been due to the rapidity with which the trunk channels have been cut through the glacial debris which gave rise to similarly rapid cutting on the part of the tributaries. It is in the canyons that many of the important mineral deposits have been located, since elsewhere bedrock is nearly everywhere covered by a mantle of superficial accumulations which renders the work of prospecting extremely difficult.

Geologically, Mayo area is not unlike other parts of the plateau. By far the greater part of the area is floored by the crystalline schists of the Yukon group* which are thought to be largely if not entirely of Pre-Cambrian age. In Mayo area these belong chiefly to the oldest division of the group, namely, the Nasina series** of McConnell and Brooks, and consist of gneissoid quartzites, quartz-mica schists, mica schists, graphite schists, hornblende schists, and crystalline limestone. In addition, a few areas of granite gneiss are intrusive into the schists.

At a few localities the older schists are cut by granitic rocks, chiefly grey, biotite granites, probably of Mesozoic age, and a few dykes of diabase, andesite, and rhyolite are known.

Mineral Resources

Until quite recently gold-bearing gravels have been the only important source of minerals in Mayo area. In the year 1914, however, with the opening up of the extremely rich silver deposit at Galena creek, much more interest was directed to lode deposits and since that time a vigorous search for similar deposits has been undertaken with the result that several promising prospects have been discovered. In addition to silver-lead properties a vigorous search has been made to locate the source of the tungsten minerals occurring in the placer gravels on Dublin gulch. This search has resulted in the discovery, within the past year, of several veins carrying tungsten minerals. Arsenopyrite-gold veins and stibnite-arsenopyrite veins complete the list of deposits known.

*Cairnes, D. D., "The Yukon-Alaska International Boundary", Geol. Surv., Canada, Mem. 67, 1914, pp. 38-44.

**McConnell, R. G., "Report on the Klondike gold fields", Geol. Surv., Canada, Ann. Rept., vol. XIV, 1901, pp. 12B-15B, and Brooks, A. H., "A reconnaissance in the White and Tanana River basins," U.S. Geol. Surv., 20th Ann. Rept., pt. 7, pp. 168-170.

Silver-Lead Properties

With the opening up of the Silver King deposit on Galena creek, much interest in argentiferous galena deposits was awakened. The Silver King mine closed down in the spring of 1918 after a short career as a producer, and when visited the workings were full of water and could not be examined. For a description of the property the reader is referred to Cairnes' report*. Though this mine has closed down the interest taken in this type of deposit has not waned and several promising prospects are being opened up, including deposits on Mt. Haldane (Lookout mountain) and Rambler hill.

Lookout (Mt. Haldane) Property

A number of claims are situated on Mt. Haldane, but serious work looking to the opening up of the deposits has been done on only one group, known as the Lookout property. This group, consisting of five claims, was staked by A. Johnson and bonded over to Messrs. J. E. Pickering, J. Greenfield, J. Anderson, and R. MacLennan. It is situated on a spur of Mt. Haldane on the western side of Bighorn creek, a tributary to the south fork of McQuesten river, at an elevation of 3,500 feet, or 125 feet above the level of the creek in this vicinity. A road has been constructed to the property, and comfortable buildings erected.

The development work includes two adits, an upper and a lower, both of which lie on the Lookout or central claim of the group. The upper adit is 50 feet in length and is terminated by a shaft following the inclination of the vein. The depth of this shaft is 25 feet measured on the slope. The lower adit lies 39 feet in elevation below and somewhat to the right of the upper. It is 59 feet long to the point where it taps the vein and from this point a drift follows the vein along the hanging-wall until immediately below the shaft, a distance of 87 feet. At this point a crosscut is being run to the foot-wall of the vein and it is intended to connect up the two sets of workings by a raise.

The country rock is a gneissoid quartzite and quartz-mica schist on the Lookout claim, i.e., to the west of the creek, and on the eastern side of the creek gneissoid quartzites and greenstone schists occur. Farther to the east a small body of greyish granite porphyry intrusive into schists is to be found.

The vein follows a well-defined but slightly irregular fracture in the quartzites, striking from 120 degrees to 150 degrees (magnetic) and dipping from 45 degrees to 50 degrees to the southwest. The thickness of the vein where first encountered in the lower workings is 7 feet, but it widens continuously towards the shaft. The outline is thus probably lenticular, but insufficient work has been done to permit of an exact determination of the shape. The vein has been explored in length for only 87 feet, but various considerations render it almost certain that it is much longer.

The vein-filling consists of galena, limonite, manganite, pyrolusite, anglesite, quartz and occasional specks of copper minerals, usually oxidation products. Angular fragments of the shattered country rock are also included. The hanging-wall is sharply defined and is marked by 1 inch to 6 inches of gouge, frequently showing an inch or more of impure graphite. The foot-wall is not very well marked, the mineralization extending into the country rock as much as 10 feet beyond the vein proper, in veins or tongue-like fissures.

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*Cairnes, D. D., Geol. Surv., Canada, Sum. Rept., 1915, pp. 27-28.

The distribution of the minerals in the vein is exceedingly irregular and follows no definite rule that has been recognized. The galena occurs plentifully along the foot-wall associated with limonite and manganese minerals. In such places it is coarsely crystalline and not particularly rich in silver. At intervals through the vein, but most frequently close to the hanging-wall, are small, irregular streaks of finely crystalline galena high in silver. The limonite is found throughout the vein. Manganese minerals such as pyrolusite and manganite are confined to the foot-wall.

The workings lie entirely within the oxidized zone. Owing to the frozen condition of the ground oxidation must have been accomplished prior to the formation of the frost zone, in which the present workings lie, as the frozen ground prevents the circulation of meteoric waters necessary to accomplish the alteration. It is, therefore, unlikely that the depth of the zone of oxidation bears any relation to the present ground water-level and probably very little to the present topography. Further the oxidation has been very incomplete.

Six samples were taken. No. 1 is a sample of all the material up to one foot from the hanging-wall; No. 2 of all material up to 2 feet from the floor of the shaft, the foot-wall not being visible; No. 3 to include the remainder of the vein lying between these two. These three samples were taken at the bottom of the shaft. No. 4 is a sample to give an idea as to the content of the foot-wall taken where the vein was first encountered in the lower adit. No. 17 is a sample of the working face taken arbitrarily on August 6. No. 18 is a sample of highly manganiferous material from the foot-wall. These were assayed and the results are listed below*.

No.	Gold.		Silver.		Total value gold and silver	Per cent lead	Remarks
	Oz. per ton	Value per ton	Ozs. per ton	Value per ton			
		$		$	$		
1	0·02	0.40	34·38	34.38	34.78	20·06	
2	Trace	....	26·20	26.20	26.20	25·15	
3	0·03	0.60	62·85	62.85	63.45	30·14	
4	Trace	....	11·10	11.10	11.10	7·20	High in manganese
17	Trace	....	8·20	8.20	8.20	10·66	
18	Trace	....	4·50	4.50	4.50	1·09	High in manganese

In addition to the vein on the Lookout claim two and possibly three other veins as yet undeveloped occur on the Wolf claim on the eastern side of the creek. These extend up over the ridge on to adjoining claims. As no development work had been done it was impossible to obtain full particulars, especially as the surface was covered with superficial accumulations. Only the weathered outcrop of two of the veins was visible and was found to be made up of limonite and manganese minerals, such as pyrolusite and manganite, like the outcrop of the Lookout vein. From the outcrop, the veins were traced up hill by means of float for a distance of over 2,000 feet. The two veins where exposed are thin and strike about magnetic north, and dip

* All assays by Wm. Sime, Territorial Assay Office, unless otherwise stated.

at 45 and 60 degrees to the west respectively. They probably intersect, therefore, a short distance below the surface.

Three samples were taken—Nos. 19, 20, and 21—to represent all the vein matter in sight near the outcrop, including both float and material in place. These gave the following results on assay.

No.	Gold		Silver		Total value gold and silver	Per cent lead	Per cent Mn.
	Oz. per ton	Value per ton	Ozs. per ton	Value per ton			
				$	$		
19	Trace	....	5·60	5.60	5.60	0·20	Not determined
20	Trace	....	Trace	....	....	0·25	Not determined
21*	Nil	....	12·66	12.66	12.66	Not determined	24·15

These results on the whole are encouraging. Though it appears that the greater part of the ore will require concentration before shipping, the ore-bodies appear to be of sufficient size to warrant the erection of a small plant for milling. With very little more work the size of the ore-bodies can be determined and then it would be possible to decide if the erection of a mill was justified. Owing to the superficial accumulations the outcrop could not be traced for any distance save by means of float which is unsatisfactory, but the Lookout vein appeared to be persistent.

Other Properties on Lookout (Mt. Haldane) Mountain

Several prospects have been staked along the strike of the Lookout vein, but on these no mineral has as yet been discovered. Other prospects are located on the eastern face of Lookout mountain, but insufficient work has been done as yet to determine their value.

Rambler Hill Property

Rambler hill is situated about 6 miles east of the foot of McQuesten lake, and on it a prospect known as the Rambler Hill property occurs well up on the hillside within 300 feet of the summit at an elevation of about 5,000 feet. The workings lie entirely above timber-line. Eight claims in all are held, owned by Messrs. A. Martin, A. Lamb, A. R. Thompson, H. Colley, J. Alverson, G. Forey, J. Lake, and J. Robertson, each of whom own an undivided eighth interest.

There is no road to the property. A wagon road reaches Galena creek some 20 miles from the property and if needed could be easily extended to the prospect, passing for the greater part of the distance through a glacial moraine, thus affording a firm, dry bed on which a road could be constructed with ease.

The country rock consists of mica schists cut by large dykes of greenstone approaching a diabase in composition. The vein is situated close to

*Assay by Mines Branch, Dept. of Mines, Ottawa.

one of these dykes, strikes approximately 70 degrees (magnetic), and is nearly vertical. The development work consists of a shaft 50 feet deep and a crosscut 10 feet long. Very little could be seen in these workings, particularly the shaft at the time of the writer's visit, as the walls were covered with ice. The total thickness of the vein is 12 feet, but this includes several horsts of barren rock.

The vein filling consists of limonite, galena, pyrite, quartz, cerussite (?), anglesite (?), malachite, and chalcopyrite. The limonite makes up by far the greater mass of the deposit. Included in it are small nodules of galena, generally about one-quarter inch in diameter, coated with oxidation products, probably cerussite and anglesite. The quartz occurs as crystals lining vugs or cavities and also as large masses. Chalcopyrite and its weathering product malachite are both rare, but occur in small disseminations, as also does the pyrite. The workings lie entirely within the oxidized zone of the deposit. The most noteworthy fact concerning this is that oxidation becomes more complete with depth. This is especially true of the galena. Near the surface and extending downwards to a depth of 37 feet are large masses of galena coated with limonite. Below, these disappear leaving only small nodules of galena. Three samples were taken, Nos. 14, 15, 16. No. 14 is a sample of the whole vein in the crosscut, including much waste; No. 15, a sample of the richer material, chiefly limonite and galena near the surface; and No. 16, a sample across 6 feet of the better mineralized portions of the vein in the crosscut. These were assayed, and found to contain:

No.	Gold		Silver		Total value gold and silver	Per cent lead
	Oz. per ton	Value per ton	Oz. per ton	Value per ton		
		$		$	$	
14	Trace	....	0·60	0.60	0.60	Nil
15	Trace	....	15·68	15.68	15.68	51·45
16	0·01	0.20	3·94	3.94	4.14	Trace

Insufficient work has as yet been done to give a true idea as to the extent of the deposit. The outcrop of the vein is concealed by superficial deposits so that it is practically impossible to trace it on the surface. The width of the mineralized zone and the content of silver in the unaltered galena (sample 15) indicate a prospect with some promise. With regard to the low values disclosed by samples 14 and 16, it was, of course, hardly likely that where the leaching has been so thorough, any values would be found.

The deposit is unfortunately situated with regard to transportation. The nearest point to which a wagon road has been constructed is Galena creek, and to continue this to the property would involve the expenditure of a large sum of money. Until sufficient work is done to prove the property to be of economic importance, such an expenditure would not be justified. On the other hand, a winter road could be constructed across McQuesten lake to the head of Beaver river. This would afford water transportation as far as Frazer falls, but some doubts are expressed as to the feasibility of this route, as the Beaver would hardly be navigable except in extremely high water.

Arsenopyrite-Gold Veins

In addition to the silver-lead veins a number of other mineral veins occur in the area, by far the greater number of which may be grouped into the one class here designated as arsenopyrite-gold veins. The most important locality is Dublin gulch, where a large number of these veins have been discovered and where considerable development work has been done on the veins.

Dublin Gulch

The rocks outcropping in the vicinity of Dublin gulch belong to two entirely distinct groups. The oldest of these is a series of schistose and gneissoid rocks composed of quartzites, quartz-mica schists, mica schists, amphibolites, crystalline limestone, and some granite gneiss. Piercing these is a body of grey biotite granite, about 3 miles long by $1\frac{1}{2}$ miles wide. The arsenopyrite veins are situated at or near the contact of this body, some lying in the schist, others in the granite, and some passing from one rock into the other without apparent change. The veins as a rule are narrow, seldom exceeding 2 feet in thickness and averaging much less, and are usually low grade. The outcrops are much weathered and are heavily stained with a greenish arsenate of iron. No attempt was made to sample these deposits thoroughly as this had already been done by MacLean and Cairnes*, and attention was paid only to veins on which recent work has been done.

Stewart-Catto Group

The Stewart-Catto group is composed of five claims and two fractions, all of which have been crown granted. These claims are located on the left side of Dublin gulch between Stewart and Olive gulches and are owned by J. S. Stewart and Dr. William Catto. About ten veins in all have been discovered but nearly all the development work has been done on three, which are known as the Green, Victoria, and Cabin veins. A number of trenches exposing the other veins have been dug, but most of these have so caved in that the veins could not be seen.

The Green vein is exposed on the left bank of Olive gulch. A considerable amount of development work has been done on it, including about 260 feet of tunnel and a raise of 27 feet, in addition to numerous open-cut trenches. The underground work includes an adit 60 feet long, which really drifts on the vein for about 50 feet. At the end of this crosscut a drift is continued along the general strike of the vein for 130 feet and from the end of this drift a 27-foot raise has been driven. Also from the main drift two small crosscuts, 40 and 30 feet long respectively, have been driven. The vein strikes almost due east and west and is nearly vertical in altitude. It varies greatly in thickness, ranging from 10 inches to 3 feet and averages, probably, about 14 inches. The vein filling is arsenopyrite in a quartz gangue. One sample, No. 24, was taken, this being cut at intervals along the vein so as to represent as closely as possible the average of the vein. For the sake of comparison four samples taken by Cairnes, Nos. 1, 2, 3, and 4, are included in the list given below.

*MacLean, T. A., op. cit., pp. 127-159. Cairnes, D. D., Geol. Surv., Canada, Sum. Rept., 1915, pp. 29-33.

No.	Gold		Silver		Total value gold and silver per ton
	Oz. per ton	Value per ton	Oz. per ton	Value per ton	
		$		$	$
24	0·35	7.00	0·65	0.65	7.65
1	0·40	8.00	0·52	0.52	8.52
2	0·56	11.20	1·09	1.09	12.29
3	0·10	2.00	0·50	0.50	2.50
4	Trace	....	Trace	....	....

On the Victoria vein a crosscut has been driven into the hill for a distance of 140 feet. This encounters two veins at distances of 85 and 100 feet, which are known as the Victoria vein and No. 2 vein, respectively. The Victoria vein strikes due east and is almost vertical; No. 2 vein strikes south 43 degrees west and is also nearly vertical. Drifts have been run along these two veins. On the Victoria vein the drift is 27 feet long to the right of the crosscut and 30 feet long to the left. In this drift the vein is 12 to 18 inches thick, and is somewhat porous and decomposed, being heavily stained with greenish iron arsenate. The filling is mainly quartz, well mineralized with arsenopyrite and pyrite. Near the end of the left drift the vein narrows rapidly and is joined by No. 2 vein, which at this point is over 4 feet thick but rather barren of mineral. One sample was taken of each of these veins—No. 22 from the Victoria vein, sampled at intervals along its length, and No. 23 from No. 2 vein. These were assayed and the results are listed below.

No.	Gold		Silver		Total value gold and silver per ton
	Oz. per ton	Value per ton	Oz. per ton	Value per ton	
		$		$	$
22	0·61	12.20	8·99	8.99	21.19
23	0·44	8.80	0·56	0.56	9.36

The Cabin vein is exposed on the surface by a line of open-cuts. In addition, an adit has been driven into the hill, which encounters the vein at 132 feet. The vein strikes south 44 degrees west (astronomic) and dips to the southeast at 65 degrees. Almost immediately beyond the point where first encountered the vein is cut off by a fault and in order to find it again 312 feet of crosscuts have been run, ultimately picking up the vein. Two samples were taken, Nos. 25 and 26. No. 25 represents the vein material where picked up again beyond the fault and No. 26 the vein close to the fault zone. These were assayed and the results are given below.

No.	Gold		Silver		Total value gold and silver per ton
	Oz. per ton	Value per ton	Oz. per ton	Value per ton	
		$		$	$
25	0·27	5.40	5·13	5.13	10.53
26	0·76	15.20	1·44	1.44	16.64

One vein recently discovered on the Victoria claim merits attention, due to the fact that from surface indications it belongs to a different type, being most likely a pyrite-gold-quartz vein. This vein is exposed in an open-cut and has a strike of south 34 degrees east (astronomic) and a dip of 52 degrees to the southwest. The thickness where exposed is $2\frac{1}{2}$ feet. The minerals of the vein-filling are pyrite, limonite, siderite, quartz, and free gold. The better mineralized portion is confined to 12 inches in the centre of the vein. This was sampled and gave the following results:

No.	Gold		Silver		Total value gold and silver per ton
	Oz. per ton	Value per ton	Oz. per ton	Value per ton	
		$		$	$
42	0·16	3.20	5.69	5.69	8.89

The Olive, Blue Lead, Eagle, and Carscallen groups were not examined as no work has been done on them for several years. For a description of these properties the reader is referred to the report by Cairnes*.

There is sufficient ore of a milling grade in sight on Dublin gulch to warrant the erection of a small milling plant in the vicinity. There seems to be no reason why concentrates of shipping grade could not be made from the deposits described above if a suitable plant were erected, and many of the deposits could doubtless be worked at a profit. It is evident, however, that none of the ores as known at present are of sufficient grade to pay for shipping to an outside point for treatment.

Christal Creek

Another property with veins of a similar type is situated on Christal creek, a tributary to the south fork of McQuesten river, entering the latter about 15 miles below McQuesten lake. Christal creek enters the McQuesten River valley through a canyon, and it is in this canyon that the veins are exposed. The prospect is the property of Axel Erickson and Fred. Swanson, and consists of one claim.

Two adits have been driven into the hill where the vein croppings are exposed. The upper adit encounters a number of small veins, the lower adit is barren of any mineral showings. The upper adit is 34 feet long and in that distance encounters two veins which will be called Nos. 1 and 2. From the end of the adit two crosscuts have been driven to the left and right. The left crosscut encounters two veins or stringers, Nos. 3 and 4. Vein No. 3 strikes south 54 degrees east (astronomic) and is vertical; vein No. 4 strikes south 20 degrees east and dips at 50 degrees to the southwest. Both are less than 5 inches thick. The right crosscut encountered two veins, No. 5 and the 'Shaft' vein. Vein No. 5 is poorly exposed, being visible only in the floor of the drift. The Shaft vein strikes south 74 degrees east (astronomic) and dips to the northwest at an angle of 60 degrees, and in reality is simply a zone of shearing in the country rock along which there has been an impregnation of sulphides, in individual crystals and in small bunches. Veins 1, 2, 3, 4, and 5 are arsenopyrite-gold quartz veins and owing to the fact

*Cairnes, D. D., Geol. Surv., Canada, Sum. Rept., 1915, pp. 29-34.

that they are thin and not very persistent are not likely to prove of economic value. In the Shaft vein, so-called because a small shaft following the inclination of the shear zone has been sunk, the thickness of the shear zone is 3 feet, and scattered irregularly through the rock are small bunches of quartz, galena, arsenopyrite, pyrite, and zinc blende. Eight samples were taken. No. 5 is a sample of vein No. 1; No. 6, a sample of vein No. 4; No. 7 a sample of vein No. 2; No. 8, of vein No. 3; No. 9 is a sample of picked material from the foot-wall of the Shaft vein, including all the best mineralized parts; No. 10 is a sample across the Shaft vein at the bottom of the shaft; No. 11, a sample across the same vein at the top of the shaft; and No. 12, a sample of vein No. 4. These were assayed and the results are listed below.

No.	Gold		Silver		Total value gold and silver	Per cent lead
	Oz. per ton	Value per ton	Oz. per ton	Value per ton		
		$		$	$	
5	0·24	4.80	1·21	1.21	5.01	nil
6	Trace	....	0·40	0.40	0.40	nil
7	Trace	....	Trace	....	....	nil
8	0·27	5 40	0·73	0.73	6.13	nil
9	0·04	0.80	10·16	10.16	10.96	3·74
10	Trace	....	0·90	0.90	0.90	nil
11	Trace	....	0·70	0.70	0.70	nil
12	Trace	....	0·25	0.25	0.25	nil

Stibnite-Arsenopyrite-Quartz Veins

Quartz veins carrying much stibnite and a little arsenopyrite have been located on the Highet Creek-Johnson Creek divide. The chief outcrop occurs on Highet dome, a hill lying at the head of Rudolph gulch which is a tributary to Johnson creek. Several small pits have been sunk, but at the time of the writer's visit these had largely become filled in so that very little could be seen of the vein.

The country rock is a gneissoid quartzite, which is intruded by several small bodies of grey biotite granite, and the deposit is situated about 2,000 feet from the contact. The full width of the vein is not visible, but from the blocks of material which have been removed it approaches 2 feet in thickness. The vein-filling consists of quartz and stibnite with a little disseminated arsenopyrite, and some of the yellowish oxidation products of antimony. One sample was taken. This is intended to represent all the vein material in sight, including that on the dump. The results of the assay are given below.

No.	Gold		Silver		Total value gold and silver	Per cent antimony
	Oz. per ton	Value per ton	Oz. per ton	Value per ton		
				$	$	
49	Nil	....	0·80	0.80	0.80	33.93

On other claims in the vicinity float has been discovered that must have been derived from thick veins of antimony, but no such veins have been discovered.

Much better deposits of antimony occur in southern Yukon[1] and these are much more favourably situated with regard to transportation than veins in the Mayo area. Notwithstanding this they cannot be worked at a profit under present conditions.

Tungsten Deposits of Dublin Gulch

In the year 1916 the placer scheelite deposits on Dublin gulch attracted considerable interest, as the demand for scheelite and other tungsten minerals became pressing. The heavy grey sand which collected in the sluice boxes during the process of washing the auriferous gravels was consequently saved and as a result several tons of high grade concentrates have been shipped. In the years 1917-18, chiefly through the efforts of Mr. Robert Fisher, the sources of this tungsten mineral were found and veins carrying scheelite are now being opened up. The writer was concerned mainly with the lode deposits, but some attention was given also to the placers.

Placer Deposits

The occurrence of scheelite in the auriferous gravels of Dublin gulch was first mentioned by Keele[2] and later by other writers, but no attempt was made to save this mineral. After the visit by Cairnes in 1916[3] the miners commenced to save it, but owing to misunderstandings which have since been removed only relatively small shipments were made. This spring (1918) over a ton of high grade concentrates were shipped, and a shipment of the same amount will probably be made before the close of navigation.

At the present time six men are engaged in working the placer gravels on Dublin gulch and are producing scheelite in addition to gold. A minor amount of wolframite is obtained with the scheelite.

Near the mouth of Dublin gulch four men, F. Cantin, P. Cantin, L. Cantin, and J. Letourneau, are working as partners on claims Nos. 1, 2, 3, 4, 5, 8, and 9 above Discovery, which is usually taken as the mouth of the creek. The depth to bedrock is from 8 to 12 feet and the width of the pay-streak is about 100 feet. The ground is worked by open-cutting and sluicing the material left on bedrock after sluicing being shovelled into boxes and washed. The gold obtained, as shown by the average for the season, is from 50 to 75 cents per cubic yard and the scheelite recovered averages from 0·8 to 1·2 pounds per cubic yard. In addition to scheelite the concentrates contain wolframite, ironstone, garnet, and other heavy minerals. Much of the wolframite is at present discarded with the ironstone. Two samples of this discarded material were taken. These assayed 51·0 and 50·75 per cent WO_3. A total of 2,500 feet of this ground remains to be worked, and the yield should be from 20 to 30 tons of concentrates. In addition to this there is much ground which was worked over in the early days when the scheelite was discarded, but it is doubtful if it would pay to work these tailing piles from which most of the gold has been extracted.

No work is being done between claims Nos. 9 and 29. On claims 29, 30,

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[1]Cairnes, D. D., "Wheaton district", Geol. Surv., Canada, Mem. 31, 1912, pp. 113-129. Geol. Surv., Canada, Sum. Rept., 1905, pp. 46-49.

[2]Keele, J., Geol. Surv., Canada, Sum. Rept., 1904, pp. 18A-42A.

[3]Cairnes, D. D., Geol. Surv., Canada, Sum. Rept., 1916, pp. 12-19.

30A, 31, 32, 33 Robert Fisher is working alone. The chief workings are situated on claim No. 30A. A small open-cut is in progress, but at the time of the writer's visit the water supply was insufficient for the purpose, and it was only by means of damming the creek and releasing the flood at intervals that progress could be made. Bedrock had not been reached, but panning showed that scheelite and wolframite were present in quantity, not only in the gravel, but also in the muck overlying it. Panning which was continued up Dublin gulch and up Olive gulch for a short distance showed that scheelite was as abundant in the tributary as in the main stream. Insufficient work has been done to permit of an estimate of the probable recovery, but the results obtained show that scheelite is present in quantities fully as great as in the workings below.

On claims Nos. 34 and 35 Wm. Steinberger has started an open-cut. As the supply of water is insufficient, Mr. Steinberger has installed an automatic dam which stores the water until a full head is obtained, discharges, and then closes automatically. The gate is 5 by 3 feet and the water at the moment of discharge has a head of 3 feet 4 inches. This device is very effective as the volume and velocity of the flow is great enough to move large quantities of material; but in low water it discharges only twice in twenty-four hours. Work on the cut had barely commenced in mid-summer, but panning showed as much as one-quarter ounce of scheelite to the pan near the surface and the amount probably increases as bedrock is approached.

No work is being done above claim 35, although scheelite undoubtedly occurs in quantity. The water supply, however, is inadequate and it is only by impounding water from the melting snow that work could be carried on successfully.

The chief difficulties in the way of successful placer mining for scheelite on Dublin gulch are lack of water and the large number of huge granite boulders which have to be moved. The first difficulty might be overcome by impounding the snow water in the heads of the gulches, as much of this runs off at present before the ice on the creek has disappeared. The second might be overcome by installation of steam derricks for the handling of the boulders. On the whole, however, it is doubtful if mining for scheelite alone would prove highly profitable. Wages or possibly slightly better might be made, but it is where gold is concentrated along with the tungsten minerals that mining operations are likely to prove successful.

Lode Deposits

Scheelite has been found at a number of points in its original associations, and a number of small surface pits and trenches have been dug exposing the veins at these localities. The discovery of these veins is chiefly due to the prospecting work of Mr. Robert Fisher who facilitated their examination in every way possible.

General Geology

Dublin gulch is floored largely by the older crystalline schists previously described, but these are cut by a body of grey biotite granite, 3 miles long by 1 mile wide, crossing the creek diagonally near the mouth of Bum Boy gulch. From what is known of the distribution and characteristics of the scheelite deposits it seems probable that the source of the mineral lies in the granitic magma from which it was concentrated into veins during the latest stages of consolidation of the igneous mass. A number of localities were examined and for convenience these may be grouped as follows:

Quartz veins. (*a*) In the granite. (*b*) In the surrounding rocks.

Pegmatites.

Quartz Veins in the Granite. The veins of this group are found at far the greater number of the known localities, and were formed probably as one of the latest stages of igneous intrusion. The veins often occur in three sets of fissures approximately at right angles to one another and vary in thickness from 1 inch to 6 inches. None of them has so far been traced for any considerable distance. The scheelite occurs as crystals both in the veins and in the wall rock adjacent to them. Quartz is usually the only gangue mineral. Calcite is sometimes present and white mica is also found affording a transition between these veins and the pegmatite deposits.

Description of Localities

The first occurrence of this class visited lies on the Bum Boy claim at the head of Bum Boy gulch. This vein was located by Robert Fisher who traced the scheelite up the gulch to the outcrop by means of panning. The granite at this point is covered by 5 feet of overburden of which 2 feet is soil and the remainder the products of decomposition in place of the granite. In this decomposed material even the grain of the original rock is still visible, however. Owing to superior resistance, the veins in it have remained unaltered. This decomposed granite carries much scheelite and at first it was thought that the whole overburden on the upland might prove to be an economic source of this mineral, but panning tests showed that the scheelite is restricted to the vicinity of veins. This point should be remembered in prospecting for other deposits.

Three quartz stringers are exposed. Two of these are nearly vertical and intersect at approximately right angles, and the third is horizontal. These stringers have a maximum thickness of 2 inches, and the scheelite occurs in crystals and grains in the quartz and adjacent wall rock. Two samples were taken. No. 27 represents the vein matter exposed in the cut and No. 28 the residual soil across a width of 5 feet, 2½ feet on each side of the vein, but not including any vein material. The results of the assays are given below*.

No.	Gold		Per cent WO_3
	Ozs. per ton	Value per ton	
27	Nil	Nil	1·80
28	Nil	Nil	0·85

A second occurrence has been located by Robert Fisher, 1,500 feet to the east of the veins on the Bum Boy claim. In this place there are three quartz stringers with thicknesses of from 4 to 5 inches. The scheelite occurs both in the veins and in the wall rock generally in crystals, some of which attain a length of over 1 inch. The decomposed rock in the vicinity of the veins contains scheelite, which in some places amounts to nearly 1 per cent

*All tungsten assays by Mines Branch, Dept. of Mines, Ottawa.

of the mass. Two samples were taken: No. 29 representing the vein material and No. 30 the wall rock for 2½ feet on each side of the veins but not including any of the vein material. The assays of these samples are given below.

No.	Gold		Per cent WO_3
	Ozs. per ton	Value per ton	
29	Nil	Nil	1·70
30	Nil	Nil	1·20

The third occurrence lies practically on the line between the Bum Boy and the Cairnes claims, and is possibly the most promising of all those so far located. There are two veins striking south 50 degrees east and south 50 degrees west respectively, and both dip steeply at 60 degrees. Three samples were taken. No. 33 is a sample of the first or more prominent vein which has a thickness of 6 to 8 inches. No. 34 is a sample of the granite adjoining the vein 1½ feet on each side. No. 35 is a sample of the adjacent granite 2½ feet on each side of the vein and No. 36 a sample of the second vein. Assays of these samples gave the following results.

No.	Gold		Per cent WO_3
	Oz. per ton	Value per ton	
33	Nil	Nil	2·60
34	Nil	Nil	—
35	Nil	Nil	Trace
36	Nil	Nil	10·10

Veins in Rocks Adjacent to the Intrusive

Only two instances of veins of this class were observed by the writer, both on the slope facing Lynx fork, a tributary to Haggart creek. The country rock is a banded gneiss composed of alternate bands of dark greenish hornblende gneiss and light-coloured mica gneiss, with occasional bands of crystalline limestone. The deposits are situated within the contact zone of the intrusive. As the deposits are similar only one will be described.

This vein lies on the Vernon claim overlooking Lynx fork and directly opposite the head of Dublin gulch. At this point a quartz vein, having a thickness of 4 inches, cuts the banded gneiss. Scheelite occurs only sparingly in the vein and is far more abundant in the greenstone adjacent, where crystals about one-half inch in length may be seen. Two samples were taken, Nos. 38 and 39; of these No. 38 represents the vein and No. 39 the mineralized wall rock. Assays of these gave the following results.

No.	Gold		Per cent WO_3
	Ozs. per ton	Value per ton	
38	Nil	Nil	1·25
39	Nil	Nil	3·40

Pegmatite Veins

The pegmatite deposits are closely associated with the quartz veins in origin; and intermediate phases between the two occur. Only one instance of a pegmatite carrying appreciable amounts of scheelite has been found. This occurs on the MacLean claim, at the head of Dublin gulch. On this claim there is a vein of pegmatite at least 1 foot in thickness and possibly slightly more, as owing to the filling of the cut with debris very little of the deposit could be seen. The pegmatite is a coarsely crystalline mass of white mica and quartz, with isolated patches of feldspar. Locally, however, a greenish hornblende makes up the bulk of the deposit. Associated with these pegmatites are tourmaline, siderite, graphite, and wolframite (?), though all of these minerals are not found at this particular locality. The scheelite occurs as crystals in the pegmatite, both in the mass and lining vugs or cavities. Small ramifying quartz veins cutting the dyke also carry scheelite.

Sample No. 37 was taken across the width of the vein exposed. It was assayed and the results are given below.

No.	Gold		Per cent WO_3
	Ozs. per ton	Value per ton	
37	Nil	Nil	6·35

Insufficient work has as yet been done on the deposits to permit of making a fair estimate of their value. Veins have been found at a few localities only; but it is probable that when the area in which the granite outcrops has been more thoroughly prospected, many more will be located. The veins as a rule are thin, but at some of the localities examined they occur sufficiently close together to form mineralized zones which possibly could be profitably exploited. If the price paid at present for tungsten should continue, it seems probable that some of these veins could be mined; but more development work is necessary in all cases to ascertain if sufficient ore is available to warrant the erection of a mill. The samples show that none of the vein material so far discovered is rich enough to pay for shipment to outside points for treatment, and consequently concentration is necessary.

There are two drawbacks which will retard the rapid development of mining on Dublin gulch; these are the limited supply of water and the remoteness of the district. Sufficient water could probably be obtained by impounding the water from the melting snow near the heads of some of the smaller gulches. Owing to the remoteness of the district, it is difficult and expensive to freight in supplies and equipment, which at present can be handled only in the winter when the sleighing is good. In the same way the output of scheelite or other ores can be freighted out only in the winter, so that for ores mined in the spring or summer a full year must elapse before returns are received. The cost of building a suitable summer road would be very high.

Scheelite Deposits on Johnson and Highet Creeks

Scheelite was first detected on Highet and Johnson creeks, as it has been on Dublin gulch, by its presence as a heavy grey sand in the sluice boxes. The amount is not nearly as great as in Dublin gulch, but the discovery has led to some prospecting for it, chiefly by Mr. P. Minton.

Scheelite was found on Discovery claim on Johnson creek and was traced up Sabbath creek, a tributary entering Johnson about 3 miles from its mouth. Tributaries entering Sabbath creek also carry scheelite, but more particularly a small gulch entering Sabbath creek $1\frac{1}{2}$ miles above its mouth. This is locally known as Scheelite gulch.

The gravels on Sabbath creek, Scheelite gulch, and the upland were panned, and it was found that the scheelite is practically confined to the areas of granitic rocks. In no case were any very rich spots found, and as it is possible to mine only very small parts of the creeks, on account of lack of water, it is reasonable to infer that Johnson creek and its tributaries cannot be reckoned as an economic source of placer scheelite. Even on those parts of the creeks where water can be obtained masses of huge boulders occur, which would render mining operations difficult and costly.

On the tributaries of Highet creek similar conditions obtain.

There is, however, no reason why scheelite should not be found in place in the area of granitic rocks which outcrop in this locality. Those places in which scheelite is most abundant on the upland are almost certain to lie directly over or slightly down hill from veins carrying this mineral, and if prospecting is carried out with this in mind, deposits of scheelite can almost certainly be located in place.

SILVER-LEAD DEPOSITS OF THE TWELVEMILE AREA

by W. E. Cockfield

The writer had an opportunity of visiting the Twelvemile area after the close of the season's work in the Mayo area. This visit was only in the nature of a preliminary examination, to gain some idea as to the extent and value of the mineral deposits, and other details which might prove useful for the purposes of comparison with the deposits of Mayo.

The writer wishes to express his indebtedness to the officers of the Yukon Gold Company who afforded him accommodation at their camps and to the employees of the same company for the courtesy and attention with which he was everywhere received.

Galena carrying high values in silver has been known for a number of years to occur in this area, but until quite recently only float had been found. Veins were recently discovered in the canyon of Spotted Fawn creek and a large number of claims were staked.

Location and Accessibility

The deposits lie within what may be termed Twelvemile area. The Chandindu or Twelvemile river is a tributary to Yukon river, joining it 17 miles below Dawson. It forks 28 miles above its mouth into two branches known as the Twelvemile and Little Twelvemile. The deposits are situated on Spotted Fawn gulch which joins the Little Twelvemile 11 miles above its mouth. The power plant of the Yukon Gold Company is situated at the forks of the Twelvemile, and from this point a wagon road has been constructed to Dawson, a distance of 40 miles. This road joins the road up the Klondike valley in the vicinity of Bear creek. From the power-plant, the flume affords a good footpath to within 6 miles of the property. From the end of the flume there is a pack trail. In winter, supplies may be hauled up the valleys of the Twelvemile and Little Twelvemile.

Topography and General Geology

The region lies wholly within the physiographic unit known as Ogilvie range. This is a spur of the Rocky Mountain system which stretches from the headwaters of Stewart river to Yukon river at the 141st meridian. This mountainous belt presents an aspect very different from that of the Yukon plateau. Beyond a somewhat general accordance of summit level it gives no evidence of ever having been planated, and probably existed as an upland tract at the time of the planation and subsequent uplift of the Yukon plateau. The range has everywhere a rugged appearance and is composed of a series of sharp ridges separated by broad, deeply-cut valleys.

The district has been intensely glaciated and all but the highest summits have been overridden by ice. The valley spurs have been truncated and the walls rounded, giving to the depressions a U-shaped outline which is characteristic. The valleys all terminate in cirque-like depressions, holding small lakes which are being rapidly filled in and reclaimed. As a result of post-glacial changes in the drainage system the streams have cut narrow trenches in the older valley bottoms, so that the valley walls are lined with rock-cut benches. Quite frequently these narrow to cleft-like canyons, and it is in one of these canyon cuttings that the ore bodies have been located.

The geology, as might be expected, differs widely from that of the Yukon plateau. The older crystalline schists are nowhere in evidence, and the greater part of the region is floored by sediments, which although greatly altered, have not developed a gneissoid or schistose structure. Intrusive into these are numerous bodies of acid and intermediate rocks. The sediments are divided roughly into two series, a lower and an upper. The lower consists of red and green slates, phyllites, banded cherts and quartzites, and some limestone. Rhythmical colour banding is quite frequent. The beds dip to the eastward at comparatively low angles. Overlying them, apparently conformably, is an exceedingly thick series of greyish quartzites and black slates, with intercalated impure sandy limestones. None of these beds so far as observed are fossiliferous. The lower beds correspond both lithologically and stratigraphically with parts of the Tindir group* of Cairnes and it seems probable that they belong to this group. Concerning the upper series there is more doubt, but it probably corresponds also to parts of the same group. If such is the case the rocks are entirely pre-Middle Cambrian in age and probably belong entirely to the Pre-Cambrian. They are cut by intrusions of granite, diorite, granodiorite, andesite, and allied rocks.

Ore Deposits

The ore deposits occur in the canyon of Spotted Fawn gulch, a tributary to the Little Twelvemile. A number of claims have been staked, but up to the present, ore has been discovered in place on only two, the Ophir and the Galena Farm. These claims form parts of a group owned by D. B. Cole,

*Cairnes, D. D., "The Yukon-Alaska International Boundary", Geol. Surv., Canada, Mem. 67, 1914, pp. 44-58.

Chris. Fothergill, C. Sproule, W. Melville, W. Elliott, and Judge Craig. At this point a dyke of porphyritic greenstone breaks through the quartzites and slates. The dyke is exposed for about 1,200 feet along the strike and has a width of 300 to 500 feet. Definite measurements of the width could not be obtained owing to superficial deposits. The veins are small fissures in the greenstone dyke, apparently being confined to it and not extending into the quartzites and slates. They traverse the dyke in a direction nearly parallel to one system of joint planes, and are characterized by splitting, chambering, and brecciation, making it apparent that they were formed under relatively slight load, probably at no great depth below the surface.

At the first locality examined, on the Ophir claim, there are two veins, nearly parallel in strike and about 4 feet apart, on the outcrop. These veins dip at different angles, and intersect about 6 feet below the surface. The maximum thickness of one vein is 16 inches and of the other 10 inches. From the thickest part both pinch rapidly in either direction, thinning to less than an inch in a distance of 25 feet. The vein-filling is a coarsely crystalline galena with pyrite and calcite, with included angular fragments of the greenstone. These are frequently partly replaced by galena. Both walls of the veins are sharply defined, very little of the ore mineral extending beyond the wall. Small specks of galena do, however, occur in the wall rock, but they are exceedingly rare. The veins were originally covered with 2 to 5 feet of gossan, composed of limonite and other oxidation products; but this gossan has been removed during the development work. Below this the galena is stained a rusty brown colour on the surface.

About 75 feet upstream from this showing, another vein occurs on the Ophir claim. It is similar in many respects to those already described, but is thinner and much more sparingly mineralized.

In addition to the veins, many of the joint planes of the dyke have galena and calcite deposited in them. These are interesting as showing how intense mineralization was in this vicinity, but owing to their size they can not be considered of economic importance.

Four samples were taken, all of them from the first locality described, which is considered as the most promising showing on the property. No. 50 is intended to represent the average of the larger vein at this locality; No. 51, the intersection of the two veins; No. 52, a sample cut at intervals along the smaller vein at the same place; and No. 53, a cut taken across the two veins, including the wall rock lying in between, to give an idea of the content per ton of material mined. These were assayed and the results are listed in the following table:

No.	Gold	Silver		Lead per cent
	Oz. per ton	Oz. per ton	Value per ton	
			$	
50	Nil	73·60	73.60	50·11
51	Nil	105·00	105.00	63·36
52	Nil	30·08	30.08	20·64
53	Nil	29·96	29.96	18·62

As may be seen from the above results the deposits are of high grade and could doubtless be worked at a profit even under present conditions of transportation and with hand methods of mining. Several hundred tons of ore could doubtless be extracted and hand-sorted for shipment, but as the veins are small, and unlikely to prove persistent in depth no large tonnage is to be expected. Such ore-shoots, however, rarely, if ever, occur singly. The conditions are such as to warrant further exploration work in the hope of encountering other bodies, and it seems probable that in order to secure results such work should be confined to the dyke rock. There is no reason for supposing that the veins already discovered are the largest and best in the immediate vicinity, as they really were discovered as the result of a canyon having formed at this place. Trenches laying bare the surface of the dyke are consequently quite likely to disclose similar bodies.

With regard to the district as a whole it may be said that the geological conditions indicate the probability of other mineral deposits. The district is one of intense igneous activity and such conditions are frequently favourable to the formation of ore deposits. The occurrence of galena float in large pieces in the canyon at points farther up than the known veins points to the existence of other ore bodies which have not yet been located.

1919

Introductory Note

The following note, by W. McInnes, Director, in his Summary Report for 1919, part A, page 1, relates to field work in Yukon Territory:

"W. E. Cockfield, in Yukon, explored geologically part of the Ogilvie Range which extends from the Mackenzie Mountains at the headwaters of Stewart River to the Yukon at the crossing of the 141st meridian. No deposits of present economic value are known within the area actually mapped, but the geological conditions are similar to those in the valley of Twelvemile River, where galena deposits occur, so that the district offers some inducement to prospectors. Prospecting, however, should be confined to those areas in the vicinity of igneous rocks.

"A few days were spent by Cockfield in examining properties in the Mayo area, where high-grade silver ore has been opened up on Keno Hill. Cockfield regards this deposit as of great importance and believes the field offers great promise to the mining man."

EXPLORATIONS IN THE OGILVIE RANGE

by W. E. Cockfield

The field season of 1919 was spent largely in the exploration of a portion of the Ogilvie range. The discovery of galena deposits at Mayo, on the outskirts of the range, and on Twelvemile river within the range itself, and the reports of copper by prospectors who had made trips across the range, made it desirable that some knowledge of the intervening country should be obtained in order to stimulate prospecting. Owing to the inaccessibility of the district and the fact that no base maps of the area were obtainable, much of the time available was necessarily spent in preliminary work including triangulation for control and ordinary mapping.

The route selected was by way of the valley of the North Fork of Klondike river. This valley and that of Twelvemile river presented the most feasible routes to the height of land, and as some knowledge of the geology of Twelvemile river* had already been obtained it was considered desirable to travel by the North Fork.

A rapid triangulation for purposes of control was carried from Dawson to the height of land, following the valley of the North Fork of Klondike river. From the mouth of the North Fork details were filled in by plane-table sketching, and in this way a map of the drainage with sketched contours showing relief was obtained. No attempt was made to make an accurate topographic map. E. Beltz and E. Hughes acted as assistants and performed their duties in a capable and satisfactory manner.

Topography

The Ogilvie range may be considered as a spur of Mackenzie mountains, extending from near the headwaters of Stewart river to the Yukon, near the crossing of the 141st meridian. Considered as a whole the range has

*Cockfield, W. E., "The silver-lead deposits of the Twelvemile area", Geol. Surv., Canada, Sum. Rept., 1918, pp. 15B-17B.

a rugged and mountainous aspect and consists of long, branching, knife-edge crests, with sharp and often precipitous peaks, separated by deeply cut valleys. The average relief of the district is about 3,500 to 4,000 feet. Beyond a somewhat general accordance of summit levels the range gives no evidence of ever having been planated, and probably was an upland tract at the time of the planation and subsequent uplift of the Yukon plateau.

The Yukon plateau is separated from the mountain province by a belt of lowland or by an old drainage channel which cuts diagonally across the present drainage courses. It has a width of from 10 to 15 miles and is floored by sands and gravels with a thickness of 600 to 700 feet. These are referred by McConnell to the late Tertiary*.

Numerous evidences of glaciation exist, especially in the upper reaches of the valleys which frequently terminate in cirques. Small lakes with rock-rimmed basins are also numerous in the higher portions of the valleys. The glaciation was local, and was apparently more intense on the northern slopes. As a result of post-glacial changes the North Fork has in several places cut deep trenches or canyons both in unconsolidated material and in bedrock and has overdeepened portions of the channel, with the result that tributary streams are depositing wide flats of gravel over which the streams flow as braided watercourses. These have a tendency to overflow in winter and thick masses of ice are formed on the flats and remain for the greater part of the summer.

The valley of the North Fork of Klondike river offers a low, flat pass into Blackstone river. The elevation of this pass is slightly less than 4,000 feet; and at the summit the valley is so flat and swampy that it is difficult to tell where the actual divide occurs.

General Geology

The part of the Ogilvie range studied during the past summer is underlain by a thick series of sediments of undetermined age, composed of cherts, quartzites and black slates, conglomerates, and red and green slates. The quartzites and black slates are intimately associated, as are also the red and green slates, the red colour being apparently due to oxidation. There is no evidence to show that these rocks are other than of one general age, and consequently they are grouped together. They strike in a general northeasterly direction, and dip generally to the northwest, although many minor folds occur. The series continues to the northwest as far as the valley of Twelvemile river**. The sediments are cut by dykes and sills and other small bodies of igneous rock including granite porphyry, diorite, diabase, and basalt. Sills form an important feature of the geology of the district. They are usually composed of diabase, and follow the strike and dip of the strata for long distances; and, in addition, govern the topography to a great extent, as owing to superior resistance they form the crests of many of the ridges and peaks.

Mineral Resources

No deposits of minerals of present economic value are known within

*McConnell, R. G., "Report on the Klondike gold fields", Geol. Surv., Canada, Ann. Rept., vol. XIV, pp. 24B-25B.

**Cockfield, W. E., "The silver-lead deposits of the Twelvemile area", Geol. Surv., Canada, Sum. Rept., 1918, pp. 15B-17B.

the area actually mapped during the past season. Large deposits of antimony are reported to occur at the head of Fish creek, and placer copper has been reported from the head of Blackstone river; but, on account of a prematurely early fall of snow which rendered it almost impossible to obtain information with regard to prospects where no underground work had been done and the urgency of a visit to the Mayo area before the close of the season, these occurrences were not seen.

In conclusion it may be pointed out that, as geological conditions are similar to those in the valley of Twelvemile river, the district offers some inducements to the prospector. Work, however, should be confined to limited areas in the vicinity of bodies of igneous rocks.

MAYO AREA

by W. E. Cockfield

Two weeks at the end of the field season were spent in the Mayo area, which, owing to the recent discoveries of argentiferous galena, appears to be at this time the most promising camp in central Yukon. No lengthy description of the geology and topography of this region need be given, as reports on the geology and economic features have already been published*; and, owing to the short time available for the visit, attention was paid only to deposits of argentiferous galena. The newly discovered properties on Keno hill were examined, as well as the properties on Lookout mountain, Rambler hill, and mount Cameron.

Development of Properties

Keno Hill

Keno hill lies between the head of Lightning creek, a tributary to Duncan creek, and Christal creek, at a distance of about 40 miles from Mayo by wagon road. The discovery of galena carrying high values in silver was made by Louis Beauvette in July 1918. A stampede to the hill took place, and upwards of a hundred claims were staked and recorded in the vicinity. Many of these have mineral showings as float, but as time did not permit of an extended examination, attention was confined largely to the original discovery and adjacent claims.

The rock exposed on Keno hill consists of gneissoid quartzites, quartz-mica schists, and mica schists belonging evidently to the series of sedimentary schists and gneisses known as the Nasina series. These are cut by a dyke of greenstone which has also been sheared to a considerable extent. This dyke, owing to differential erosion, projects about 50 feet above the surrounding rocks and forms an important topographic feature. It extends in a general east-west direction and forms the top of the ridge known as Keno hill, the summit of which is 6,400 feet above sea-level. The greater part of the ground staked lies above timber-line.

The ore deposits are fissure veins occurring both in the dyke and in the surrounding country rock. At the time the property was visited very

*Keele, J., "Upper Stewart River region", Geol. Surv., Canada, Ann. Rept., vol. XVI, pt. C. Cairnes, D. D., Geol. Surv., Canada, Sum. Rept., 1915, pp. 10-34. Cockfield, W. E., Geol. Surv., Canada, Sum. Rept., 1918, pp. 1B-15B.

little stripping work had been done, and most of the exposures consisted only of debris or float which was exposed on the surface. Consequently, very little idea could be obtained as to the value and extent of the deposits.

A group of six claims has been staked around the original discovery and bonded to the Yukon Gold Company which is doing the necessary development work to prove the value of the claims. The claims are the Roulette, Keno, Rico, Pinochle, Scottie, and Heather. There were five main showings of mineral on the claims; three on the Roulette and two on the Keno. The original discovery on the Roulette claim is a vein occurring in a small gulch opening into Ladue valley. At the time of the writer's visit it was largely covered by debris; but values in silver of 150 ounces per ton and upwards had been obtained from a series of samples taken by the holders. The main showing on the property lies at the shoulder of the hill, on the Roulette claim, very close to the border of the Keno. Stripping had uncovered a vein with a width of 6 feet striking approximately north 10 degrees east magnetic and dipping approximately 55 degrees to the east. The vein is stripped along the slope of the hill for about 20 feet, the upper 10 feet showing massive galena. The vein is then apparently cut off by a horse of country rock, but resumes immediately below. The width of the vein below the horse could not be accurately determined, but it is at least one foot and possibly more. The values obtained from this vein were as large as those of the original discovery or slightly higher. On the summit of the hill a third vein has been uncovered in the dyke rock. It has a width of one foot and like the other is massive galena. The dip and strike of the vein could not be accurately measured at the time of the writer's visit; but it is apparently a different vein from that previously described.

At other points on the surface of this group galena float occurs in such places as to make it certain that it comes from veins other than those described above. In many cases it is probable that the outcrops are not far away and that the material has been brought to the surface by frost action; in other cases solifluction or land creep has been active and it is impossible to say how far away the outcrops are. It will, therefore, require a systematic series of trenches to reveal all of the veins on the property.

Promising showings also occur on two claims owned by T. McKay and Axel Erickson. One of these claims is situated at the head of a small gulch tributary to Christal creek about a quarter of a mile to the east of the Heather claim. The vein was uncovered by a small open-cut running into the hillside, but owing to slumping no particulars concerning it could be obtained other than that the vein strikes in a general northerly direction. A good showing of vein material occurs on the dump and grab samples taken by the owners and assayed by the Territorial Assay office at Whitehorse run from 100 to 1,000 ounces in silver.

The second of these claims, the Nabob, adjoins the Keno on the northeast. The vein is exposed in a small cliff face, but owing to talus very little of it could be seen. It strikes in a general east-west direction and dips about 45 degrees to the south, and has a thickness of from 4 to 6 feet. Grab samples taken by the owners show values similar to those from their other claim. The vein-filling is composed of galena, iron minerals, and quartz.

The Silver Basin, owned by R. Rasmusen, lies about three-quarters of a mile to the northeast of the Keno. The vein matter exposed is not in place, but, in a small slide of debris from a rock chimney, occurs in such a manner that it could have come only a short distance. The vein material consists of iron carbonates and hydroxides, quartz, arsenopyrite, and galena.

On a number of other claims, finds of mineral have been reported and it seems probable that mineralization has taken place over a wide area, but owing to the fact that so little can be seen of any of the deposits, no conclusions can be drawn as to their origin or extent. It seems probable, however, that further prospecting will add greatly to the area around Keno hill where mineral has been discovered.

The prospects already discovered all contain a high grade ore which will stand mining and shipping even under adverse conditions, and many of them could be worked by hand methods of mining. The size of the deposits has yet to be determined, and this will be done in a number of cases during the present winter. If the ore bodies are found to be of sufficient size, the construction of a good wagon road to the property would be necessary, as the present road, though good for winter haulage, would be absolutely impassable for heavy traffic during the summer. It is possible that hauling will take place to Gordon Landing rather than to Mayo as the route would be 10 miles shorter.

Mount Cameron

Mount Cameron is situated about 45 miles in a direct line northeast of Mayo and the distance by the winter road now under construction to the property is approximately 65 miles. The Mount Cameron property is situated on the northern slope of Mount Cameron at timber-line or approximately 3,500 feet above sea-level. It consists of three claims, Cameron No. 1, Cameron No. 2, and Cameron No. 3, owned by J. Alverson and J. Scougale.

The general geology of the district is similar to that of Keno hill, the country rock being composed of gneissoid quartzites, quartz-mica schists, mica schists, and crystalline limestone, cut by dykes of diabase.

The workings consist of an adit 30 feet long and a crosscut 12 feet long. The mouth of the adit was blocked by caving at the time of the writer's visit, and consequently the underground workings could not be examined. The outcrop of the vein consists of a decomposed mass of iron and copper minerals; pyrite, limonite, siderite, malachite, azurite, and arsenopyrite; with galena, sphalerite, and calcite. The width of the mineralized cropping is about 50 feet. It is claimed that in the adit the vein has a banded appearance with alternating streaks of galena and sphalerite, the galena occurring in streaks from 2 inches to 6 inches wide.

It is not possible at the present time to make a fair estimate of the value of this property; the size of the cropping and the fact that streaks of pure galena carrying high values in silver occur, indicate that it may have considerable value, but much more development work is necessary in order to prove this. This work should include both sinking and drifting.

Rambler Hill

A description of the Rambler hill property has already been given* and nothing can be added to it at present; for work had just been commenced at the time of the writer's visit. It is the intention of the owners to sink the shaft to a depth of 200 feet during the coming winter.

*Cockfield, W. E., Geol. Surv., Canada, Sum. Rept., 1918, pp. 6B-7B.

Lookout Mountain

The Lookout property has been taken over by the Yukon Silver-Lead Mining Company, an organization of local capitalists. The property consists of a group of five claims and several fractions, situated on a spur of Lookout mountain, on the western side of Bighorn creek, a tributary of McQuesten river. The outcrop is situated at an elevation of 3,500 feet or 174 feet above the level of the creek.

The development includes about 930 feet of underground work. The upper adit is 50 feet in length and is terminated by a winze 25 feet deep, following the inclination of the vein. A second adit 39 feet below the upper and 90 feet to the north of it, is 59 feet long to the point where it taps the vein, and from this point a drift follows the vein until directly below the winze, and an upraise has been stoped to within 6 feet of the bottom of the winze. The third adit is 125 feet below the second, and 320 feet to the north. It is 135 feet long to the point where it taps the vein, and a drift following the vein has been run in a southerly direction for a distance of 305 feet. Forty feet from the point where the adit taps the vein, a winze was sunk on the vein to the fourth level, a distance of 55 feet measured along the slope, and 100 feet beyond an incline has been sunk to a depth of 90 feet. The fourth level was driven from the incline to the winze and extended north a few feet.

The vein follows a well-defined but irregular fracture in a gneissoid quartzite and quartz-mica schist. It strikes from 120 degrees to 150 degrees magnetic and dips from 45 to 55 degrees to the northeast. The filling consists of manganite, pyrolusite, limonite, cerussite, anglesite, galena, and quartz. The hanging-wall is usually well-defined and marked by gouge, frequently showing an inch or more of impure graphite. The ore is of a disseminated character, the galena occurring in small streaks and masses. There are, however, several zones in which the streaks of galena occur in sufficient numbers to permit of sorting a shipping grade of ore. The uppermost of these was encountered in the prospecting shaft sunk from the upper adit. The size of this zone has not been determined, as it does not appear in the lower workings. In the second adit there are no well-defined zones, and although galena occurs plentifully along the foot-wall in a gangue of manganese minerals, it is as a rule more coarsely crystalline and carries less silver. In the third level there are two streaks of carbonate ore carrying very high but somewhat erratic values in silver. These streaks vary from 1 inch to 12 inches in thickness. Two zones occur between the third and fourth levels, one being in the winze and the other in the incline. Neither of these has been fully blocked out, but the ore-shoot occurring in the incline is probably the largest yet found. Five samples were cut across the portion of the ore-body that is exposed in the workings, four of the samples (Nos. 1 to 4) being taken in the incline, two above and two below the fourth level, the intervals between samples being 10 feet. Both sides of the incline were sampled and the material from the two cuts included in the one sample. No. 5 is a sample taken from the fourth level 10 feet from the incline. The samples were assayed* and the results are listed on next page.

*Assays by W. C. Sime, Territorial Assay Office, Whitehorse.

No.	Gold, ozs. per ton	Value gold per ton	Silver, ozs. per ton	Value silver per ton at $1.20	Total value gold and silver per ton	Lead per cent
		$		$	$	
1	0·02	0.40	43·48	52.17	52.57	29·80
2	0·01	0.20	34·34	41.21	41.41	28·20
3	Trace	....	37·20	44.64	44.64	40·60
4	0·03	0.60	45·57	54.68	55.28	36·60
5	Trace	....	28·80	34.56	34.56	23·20

Development work at this mine is still proceeding. The incline is being sunk to water-level, and it is the intention of the owners to stope out and sort for shipment the ore occurring between the third and fourth levels.

Conclusions

From the data that have already been collected in Mayo area, it is becoming increasingly more evident that the silver deposits occur in areas where the schists of the Nasina series have been cut by intrusions of basic and semi-basic rocks. The relation holds in too many cases to be of an entirely accidental character, and it would appear that there is a genetic relation between the two. This, however, can hardly be established until work of a detailed nature has been undertaken. Greenstones of two widely different ages are present, however, one being Pre-Cambrian and the other late Palæozoic or early Mesozoic. Both have apparently been epochs of mineralization, but until the areal geology of the district has been done very little can be said as to the effects of these intrusions. Some evidence also exists to show that the region has been subjected to earth movements subsequent to the formation of some of the ore deposits, and that the veins have undergone metamorphism.

The discovery of deposits of high grade ore on Keno hill is of great importance, as it shows beyond doubt that the Silver King vein is not an isolated occurrence. That other discoveries will be made from time to time seems highly probable. Nuggets of native silver are common in the placer gravels of the district. These have largely come from within the area itself, and represent portions of veins which have been eroded away. The field is consequently one that offers great inducements to the prospector, and it seems probable from what has already been discovered that areas where greenstones cut through the schists are the most likely places to prospect for silver deposits.

1920

Introductory Note

In 1921, the Director, W. H. Collins, includes the following note on field work in Yukon Territory in the Report of the Department of Mines for the fiscal year ending March 31, 1921, page 6:

"W. E. Cockfield made a detailed investigation of the Keno Hill silver-lead ore deposits near Mayo, Yukon. High grade ore is being taken from a number of these deposits and much attention is, in consequence, being given the district by prospectors. A detailed geological map of the Keno Hill area and a report dealing with the nature, distribution, and theory of origin of the ore deposits appear in the Summary Report of the Geological Survey, Part A."

SILVER-LEAD DEPOSITS OF THE KENO HILL AREA, MAYO DISTRICT

by W. E. Cockfield

A detailed geological investigation of the ore deposits of Keno hill, Mayo district, was made in the summer of 1920. Two and a half months were spent on the field work, and the writer was ably assisted by P. F. Armstrong, W. G. Cuttle, and C. A. Merritt. The work included the preparation on a field scale of $\frac{1}{12,000}$ of the topographic map that accompanies this report.

The writer wishes to acknowledge his indebtedness to the officials of the Yukon Gold Company for information freely placed at his disposal and for many other courtesies.

Location and Accessibility

Mayo district takes its name from the town of Mayo, which is situated on upper Stewart river, 180 miles above its confluence with the Yukon. All parts of the area are readily accessible. During the summer months a regular passenger and freight service is maintained by the White Pass and Yukon route.

Keno ridge is a ridge about 10 miles long and 5 miles wide lying between Christal and Lightning creeks and Ladue river. The distance from Mayo by wagon road is about 42 miles.

The rates charged for freight vary greatly. From Dawson to Mayo the freight rate is from $50 to $60 per ton, depending upon the stage of water in Stewart river. The freight rate from Mayo to the summit of Keno hill is 15 cents a pound by wagon and about half that amount by sled in the winter. Ore is usually handled by contract and can be shipped from Keno hill to smelters on the Pacific coast for about $60 per ton.

Topography

Mayo district lies entirely within the physiographic province known as Yukon plateau. It is characterized by being subdivided into isolated mountain groups, separated by broad, flat-bottomed valleys. The inter-stream areas are mostly flat-topped and stand at an average elevation of

5,000 feet, the elevation increasing slightly toward the east. These upland areas are parts of a former plain-like surface, which has been uplifted and dissected.

The district has been intensely glaciated, all but the upland having been covered by ice which rounded, smoothed, and scoured the valley walls, giving to them typical U-shaped cross-sections. The valleys are floored with glacial accumulations through which the streams have cut, forming terraces.

By far the greater part of the area is floored by the crystalline schists of the Yukon group* which are thought to be Precambrian. In Mayo district these belong chiefly to the oldest subdivision of the group, namely, the Nasina series**, and consist of gneissoid quartzites, quartz-mica schists, mica schists, graphite schists, hornblende schists, and crystalline limestone. These schists are cut at some localities by later igneous rocks, chiefly greenstones and granite.

The area mapped during the past summer consists of a ridge about 10 miles long and 5 miles wide, lying between Christal and Lightning creeks and Ladue river. The ridge is long and wedge-shaped, with a flat top and is surmounted by five hillocks rising a few hundred feet above the general level. These are known as Keno hill, Minto hill, Monument hill, Caribou hill, and Beauvette hill. All except the very lowest slopes of the ridge is above timber-line. The summit of the ridge stands at an elevation of 6,346 feet above sea-level, and the bulk of the properties on which work has been done lie quite close to the summit.

The northern slope of the ridge is very steep, but is broken by a series of benches, formed by outcrops of the harder formations. These benches slope gently toward the hill, but their outer limits are bounded by steep, even precipitous, slopes. A prominent sill of greenstone projecting almost 100 feet above the surrounding rocks forms the summit of Keno hill. This sill has a cliff face to the north and forms a topographic feature that can be recognized for long distances.

A number of small gulches drain outward from the ridge, and are tributary to the larger drainage courses. These gulches are steep in grade and mostly rise abruptly in semicircular basins. The more important gulches draining to the north are Gambler, Faro, and Silver Basin; draining to the south, Faith, Hope, and Charity; and to the west, Erickson.

General Geology

The greater part of the area is underlain by crystalline schists which are intruded by sills of greenstone and dykes and sills of quartz porphyry and granite porphyry.

The crystalline schists consist of a banded blue and white gneissoid quartzite, grading in places into a quartz-mica schist, sericite schist, graphite schist, and crystalline limestone. These occur in bands more or less continuous across the mapping sheet. The greenstone is intruded as sills, usually into the softer schist formations. These sills are conformable in strike and dip with the intruded schists. Like the schists they have undergone deformation, but have suffered less in this respect than the rocks they intrude. In

*Cairnes, D. D., "The Yukon-Alaska International Boundary", Geol. Surv., Canada, Mem. 67, 1914, pp. 38-44.

**McConnell, R. G., "Report on the Klondike gold fields", Geol. Surv., Canada, Ann. Rept., vol. XIV, 1901, pp. 12B-15B.

places they have a decidedly schistose appearance, but in general are quite massive, though possessing a pronounced cleavage in one direction. The greenstones vary considerably in colour, texture, and composition, ranging from a diorite to a diabase. Owing to their superior resistance, they form important topographic features.

The quartz porphyry and granite porphyry occur as dykes and sills which in general conform in strike to the bedding of the rocks they intrude, but in some instances they cut across it, and in such cases clearly show that they are the latest consolidated rocks of the region. They are believed to be apophyses of a large granite body which outcrops 10 miles to the east, and which undoubtedly extends widely beneath the known strata of Mayo district.

Overlying all the consolidated rock formations there is a mantle of superficial deposits, which nearly everywhere masks the underlying rocks and renders prospecting difficult.

The general trend of the strata is in an east-west direction, and they dip to the south at relatively low angles. However, near the hillocks known as Keno hill, Minto hill, and Monument hill, the strata undergo a sharp flexure, bending nearly at right angles, and continue in a southerly direction across Lightning creek where they gradually resume their former course. This flexure is believed to be the cause of the numerous small local faults which occur in the vicinity, and which have such an important bearing on the ore-bodies.

Economic Geology

Ore-Bodies

The ore-bodies are found in fissure veins and are consequently bound up with the systems of faulting. Two of these systems have been recognized. Owing to the main system having a general trend of north 30 to 40 degrees east (magnetic)* and running in a general way parallel to the trend of the formations, these systems will be called for purposes of reference, longitudinal faults. The main system is composed of one main fault, which crosses from Beauvette hill on the east to Caribou hill and thence across the top of Silver Basin gulch, a distance of over 2 miles. Near Silver Basin gulch this fault diverges into three branches, one of which crosses Minto and Keno hills and the others the top of Faro gulch. Towards the western portion of the mapping sheet these die out or their effect is obscured by the mantle of superficial deposits. Traces of other faults parallel to these have been found but they could not be traced any distance for the same reason.

The second system of faults will be referred to in this report as transverse faults because they are, in general, found cutting across the strike of the formations. Their strike is from north 5 degrees west to north 15 degrees east (magnetic), and as a rule they are short and of comparatively slight displacement. As already pointed out these faults are exceedingly numerous in the vicinity of the local folding referred to above.

The longitudinal faults are mineralized with quartz, arsenopyrite, siderite, manganese, and galena; the transverse faults are mineralized with quartz, calcite, galena, blende, manganese, and siderite, and enriched with a silver salt, not yet positively identified but believed to be freibergite ($4(Cu\ Ag)_2S.Sb_2S_3$), a sulphantimonide of copper and silver.

*Declination 1920, 37° 20′ east.

The principal ore-shoots already discovered lie in the transverse faults and consequently work on these faults has progressed to a greater extent than on the longitudinal faults. From what has already been learned it may be established as a general rule that where a transverse fault taps one of the longitudinal faults and passes upward out of a hard stratum such as quartzite or greenstone into schist, an ore-shoot is usually found in the vein beneath the schist, as if the latter had acted as an impervious barrier to the ore-bearing solutions and had forced deposition of their load at that point. Development has not yet been carried to the point where it can be affirmed that the schist is barren of ore, and that ore-shoots occur only beneath schist cappings, but it is well established that such places are exceedingly favourable for ore-bodies.

In the longitudinal veins ore deposition has taken place at localities where the veins have been opened by a distinct fracture, i.e., probably contemporaneously with the formation of the transverse faults. At other points, however, the ore is of a disseminated character and may possibly have been introduced at the time of formation of the longitudinal faults. Consequently no general rule for the distribution of ore-shoots in longitudinal veins can be formulated at present.

No samples for assay were taken by the writer as the content of the ore is well known. The galena usually occurs fairly pure, i.e. free from mixture with gangue minerals. In such cases it assays from 200 to 500 ounces of silver a ton, but in places it goes much higher, reaching 2,000 ounces. In such cases, however, it usually contains freibergite. The lead assays usually average about 60 per cent. These values it must be understood are for samples of the ore-shoots and are not for the full width of the veins.

Mining Operations

Upwards of 600 claims have been staked on Keno hill and in its vicinity. Naturally on the majority of these only representation work has been done. Serious development work has been performed on only two or three groups.

The Yukon Gold Company secured options on a number of claims, which they have been prospecting vigorously. Their main group consists of the Roulette, Keno, Scotty, Solo II, Pinochle, Wolverine, and Rico, and in addition a number of outlying claims are being prospected such as the Caribou, Gold Hill, Ladue, and Lucky Queen.

The principal workings of the Yukon Gold Company lie above timberline at an approximate elevation of 5,800 feet above sea-level, on the small knoll known as Keno hill and on the steep slope at the head of Faro gulch. They comprise a series of shafts, tunnels, and surface trenches. The three branches of the main longitudinal vein and a number of transverse veins cross the property.

The most northerly of the longitudinal veins is known as No. 1. This vein strikes north 35 degrees east (magnetic) and dips 60 degrees to the southeast. It is from 3 to 7 feet in width, mineralized with quartz and arsenopyrite, and has been explored by three tunnels 230 feet, 140 feet, and 150 feet long. These tunnels are about 60 feet apart along the dip of the vein and the upper two are connected by a winze. These tunnels have tapped an ore-shoot which has an approximate length of 60 feet and thickness of 14 inches, formed in a distinct fracture in the vein.

A second longitudinal fracture runs along close to the top of the slope of Faro gulch. This vein is in a general way parallel to No. 1. It strikes north 40 degrees east (magnetic) and dips 45 degrees to 50 degrees to the southeast. It is similar in type to No. 1 vein, i.e. a quartz-arsenopyrite vein, but no decided ore-shoots have been found in it up to the present. A number of transverse veins intersect it, however, and give rise to some of the more important veins of the property. These are Nos. 3, 7, 8, 9, and possibly also Nos. 4 and 5. No. 3 vein strikes north 23 degrees east (magnetic) and is practically vertical. It has been explored to a depth of 80 feet by a shaft. It averages 3 feet in width and is well mineralized with galena. No. 4 vein is considered to be the continuation of No. 9, a flat underlain by schist, through which the vein has not been traced, intervening between the two. This vein which is approximately 3 feet wide, strikes north 10 degrees east and dips 75 degrees to the southeast. An ore-shoot showing 2 feet of massive galena occurs on the slope overlooking Faro gulch. No. 7 vein strikes north 15 degrees east and dips at 47 degrees to the southeast. It has a thickness of 3 feet. No. 8 vein is in reality a sheeted zone with a thickness of 3 feet.

A third longitudinal vein crosses the southeastern edge of Keno hill and the western edge of Minto hill. It shows the typical quartz-arsenopyrite mineralization with some galena.

The Caribou claim is situated on Caribou hill. The workings consist of surface trenchings. On the summit of the hill the vein is about 5 feet in width striking south 45 degrees east and dipping 72 degrees to the northeast. The mineralization consists of 5 to 8 inches of galena in a gangue of carbonates, oxides, and quartz. The outcrop may be traced along the northern slope of Caribou hill. A considerable body of disseminated ore is found below the intersection of this vein with a flat-dipping one.

McKay and Erickson's Workings

Mining work is in progress on two groups of claims owned by McKay, Erickson, and Beauvette. One of these groups situated at the head of Erickson gulch, comprises the Shamrock, Reno, Kid, Lion, and Tiger claims. Development work consists of 200 feet of drifts and a 15-foot winze. There are two main veins varying in width from 2 feet maximum to a seam, the dips varying from 45 to 90 degrees. There are in addition a number of small slip faults. The mineralization consists chiefly of galena, carbonates, and iron oxide. About three tons of galena was stoped from these workings and shipped but returns were not available at the close of the season's work. Very little unaltered galena was encountered in these workings which are, however, within 40 feet of the surface.

Nabob Claim

McKay and Erickson are also operating the Nabob claim, at the head of Faro gulch, immediately to the east of the Rico claim of the Yukon Gold Company. The vein here is the one described as the central longitudinal vein on the Yukon Gold Company's property. An incline 10 feet in depth has been sunk and considerable disseminated galena was encountered. The property also has several transverse faults intersecting this main vein and it is considered likely that ore-shoots will be found in these as development work continues.

Rasmusen's Property

Rasmusen's claims are situated on the western side of Silver Basin gulch and consist of the Silver Basin, Silver Basin IV, Diorite, and Silver Gulch. A main longitudinal fault striking north 30 degrees east and dipping 65 degrees to the southeast cuts across the property. This has the typical quartz-arsenopyrite mineralization, with some galena. Four transverse faults intersect this main fault and pass upward from the quartzites into the schists. The chances for mineralization at these points have already been pointed out. The work done consists of some open-cuts and trenches, but is insufficient to show the true value of the property.

On a number of other claims, assessment work has been done, but in most cases this has not progressed far enough to expose the veins in place.

Conclusions

The high-grade ore in the transverse fissure offers little difficulty either in finding or extracting. On the upland surface these fissures can frequently be traced by the iron, manganese, and galena float, which is usually close to the outcrop of the vein. As the superficial deposits are generally thin, the task of finding the veins is comparatively easy. On the lower slopes of the ridge, however, where the drift cover is thicker and where the float may be some distance from the outcrops, the prospector's task is more difficult. Good results may be obtained by ground-sluicing with snow water in the spring. The extraction of the ores also offers few difficulties, as most of them are rich enough to pay for mining by hand methods, and in most cases concentration is unnecessary.

In considering the future of the camp it must be remembered that some of the transverse fissures are quite short and are not likely to continue to great depths, but this is compensated for, to some extent, by the large number of these veins. The longitudinal veins, on the other hand, are more persistent, and are more likely to prove continuous with depth. As these fissures undoubtedly served as the main channels for the circulation of the ore-bearing solutions, there is some likelihood of ore-bodies being found in them. Whether these will be of the same high grade character as the ore found near the surface cannot be foretold. It is believed, however, that the permanency of the camp depends to a large extent on the character and size of the ore-bodies contained in these fissures.

1921

Introductory Note

The following note, by the Director, W. H. Collins, relative to field work in Yukon Territory, is contained in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1922, pages 4, 5:

"W. E. Cockfield made detailed topographical and geological maps of three small areas (Stand-to Hill, Rambler Hill, and Mount Cameron) in the vicinity of Mayo, Yukon Territory. These areas are mineralized with veins carrying silver-lead ores similar in origin to the rich silver-lead mines at Mayo, and constitute outlying parts of one mineral district. A full report of Cockfield's work, illustrated with three geological maps, appears in the Summary Report of the Geological Survey, Part A."

SILVER-LEAD DEPOSITS OF DAVIDSON MOUNTAINS, MAYO DISTRICT

by W. E. Cockfield

The investigation of the Mayo silver-lead ores was, during the field season of 1921, confined to the mapping of three small areas in Davidson mountains, on which some prospecting had been done. These areas—Stand-to hill, Rambler hill, and mount Cameron—comprising a total of slightly more than 60 square miles, were mapped on a scale of $\frac{1}{12,000}$ and the maps (Nos. 1937, 1940, 1943) accompany this report.

The writer was ably assisted by N. T. Ellis, C. A. Merritt, and T. D. Guernsey, all of whom performed their duties in a satisfactory and efficient manner. Mr. Ellis was in charge of the topographical mapping, and Mr. Merritt and Mr. Guernsey assisted in both the topographical and geological work. The miners and prospectors of the district assisted in every way possible and for the many courtesies and favours received the writer wishes to express his hearty thanks.

General Character of the District

Location and Accessibility

Mayo district takes its name from the town of Mayo, on Stewart river, 180 miles above its confluence with Yukon river.

Davidson mountains occupy the area enclosed by Ladue, McQuesten, and Beaver valleys, and form a range 30 miles long and 12 miles wide, having a general east-west trend. In general the southerly slopes of the range are gentle, being governed to some extent by the dip of the strata; the northerly slopes are steep, frequently precipitous. This also applies to those stream valleys flowing in an easterly or westerly direction within the range. Numerous sharp peaks occur, the highest of which is mount Cameron (6,893 feet).

The position of the areas with respect to Mayo is shown on Figure 4.

During the summer a regular passenger and freight service is maintained on Stewart river by the steamers of the White Pass and Yukon route. From Mayo, roads lead to all the principal creeks. The most direct route to the properties under discussion is by way of Galena creek. A winter road leads from Galena creek to mount Cameron, and a trail leads from this

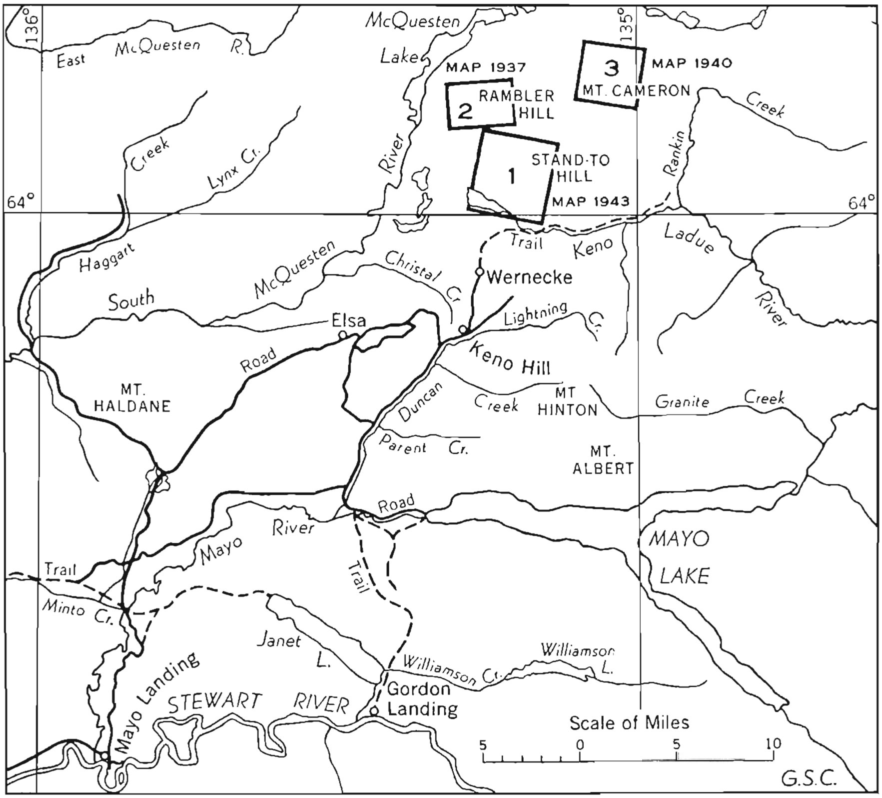

Figure 4. Index map showing location of mineralized areas, Mayo district, Yukon.

1. Stand-to hill area.
2. Rambler hill area.
3. Mount Cameron area.

winter road across Ladue lakes to Stand-to hill, and another, up Cache creek to Rambler hill. A better road for summer traffic leads to the base of Keno hill, where there is a trail down Christal creek to the Mount Cameron road.

The rates charged for freight vary greatly. From Dawson to Mayo the freight rate is from $50 to $60 a ton, depending on the stage of water in Stewart river. Ore at the present time is hauled 42 miles from Keno hill to Mayo for $30 a ton. The freight rate from Mayo to Keno hill is 15 cents a pound in summer and about half that amount in winter. In considering the three areas covered by this report it must be remembered that at present summer haulage is out of the question, there being no road, and that owing to greater distance and poorer roads winter haulage would be more expensive than to Keno hill.

Topography

Mayo district lies within the physiographic province known as Yukon plateau, which is in this district characterized by its subdivision into isolated mountains groups, separated by broad, flat-bottomed valleys. The inter-stream areas are mostly flat-topped and stand at an average elevation of 5,500 feet. These upland areas are parts of a former plain-like surface which has been uplifted and dissected. Occasional hills rise from the plateau to heights of 500 to 1,000 feet.

The district has been intensely glaciated, all but the upland having been covered by ice, which scoured the valley walls, giving to the valleys typical U-shaped cross-sections. The valleys are floored with glacial accumulations, through which the streams have formed terraces.

General Geology

Mayo area as a whole is floored by crystalline schists and gneisses. These are the oldest rocks of the district, and, by analogy with similar districts where the age of the rocks has been determined, they are tentatively referred to the Precambrian. These schists and gneisses consist of banded blue and white gneissoid quartzites, grading into quartz-mica schists, and mica schists, graphite schists, and crystalline limestone. These schists are intruded at many points throughout the district by later igneous rocks, diorite and diabase, granite, quartz porphyry, and granite porphyry.

These conditions also obtain in Davidson mountains—one of the three groups referred to above—where the greater part of the areas mapped consists of banded blue and white quartzites, quartz-mica schist, mica schist, graphite schist, and crystalline limestone. Cutting these are dykes and sills of greenstone, which vary widely in colour, texture, and composition, ranging from diorite to diabase, but which appear to belong to one general age of intrusion. These have been intruded along the bedding planes of the schists and have been subsequently sheared and altered. Many of them have become so altered, and now consist to such an extent of secondary minerals, that it is difficult to determine what their original compositions were. In the field they are nearly always well-defined owing to their dark green colour, different texture, and the fairly sharp dividing line between them and the schists. Owing to their superior resistance they frequently control the topography and form the crests of the ridges.

The granitic intrusives are more prominent in Mayo district than in those parts of Davidson mountains that have been mapped; but one small body of granite was found in Stand-to hill area, occurring well down on the slope toward Ladue valley. This occurrence is distinguished by the presence of muscovite, whereas in all other granitic occurrences observed in the district biotite is the predominating ferromagnesian mineral.

Overlying all the consolidated rock formations is a mantle of superficial deposits of varying thickness. It is thickest in the valleys, where boulder-clay and stream deposits cover bedrock, but it is also prevalent on the hillsides and even on the upland surface where soil, frost-heaved blocks of bedrock, rock rubble, and talus make outcrops scarce. Outcrops are most numerous along the crests of ridges, particularly at the edges of the steep northerly slopes referred to above. They also occur in small jagged peaks at irregular intervals along the upland surface. On the hillsides rock outcrops are rare and are usually of the more resistant rocks, such as greenstone. In the valley bottoms there are occasional outcrops, particularly in the small canyons on the creeks.

Economic Geology

The silver-lead ores of Davidson mountains are the only known deposits of economic value. They have many characteristics in common and are presumably similar in origin. They are veins formed by the filling of fault fissures. The ore mineral is galena in a gangue of siderite and quartz, with which is associated manganite, and in some cases pyrite, chalcopyrite, and zinc blende.

Description of Deposits

Stand-to Property

The Stand-to property (Map 1943) is situated on the east side of Homestead creek about 2 miles from its mouth. The workings are about 500 feet above the creek level. There is no road to the property, a winter trail from the workings across Ladue lakes to the Mount Cameron road—5 miles distant— being sufficient for its present needs.

The Stand-to property comprises seven claims, Elsie, Dorothy Brown, Janet Agnes, Two Donalds, Victoria, Mary Bell, and Glengarry, owned by J. Zahn, W. Forbes, D. Forks, D. MacDonald, J. Falconer, and J. A. MacDonald. These claims are grouped for the purpose of representation on the map. They were staked August 15 and 16, 1920. At the time of the writer's visit (July, 1921) the workings consisted of a number of surface trenches, and a 50-foot adit on the vein, about midway between the creek and the summit of Stand-to hill.

The vein is formed in a fault fissure which at the elevation of the workings brings a band of schist into juxtaposition with a greenstone sill, the fault having a vertical displacement of about 50 feet. The vein has been traced on the surface by open cuts for 200 feet, but probably extends farther in both directions, for in this vicinity bedrock is covered by soil and talus, and the extent of the vein can be ascertained only by trenching. The average strike of the fissure is south 50 degrees east (magnetic); the dip is about vertical. The trend, however, is irregular, for the vein is broken by slip faults. The vein, which varies in width from 16 inches to 2 feet, is mineralized with galena, calcite, siderite, cerussite, limonite, manganite, chalcopyrite, and quartz. The galena occurs as bands from 1 inch to 6 inches wide in the other gangue minerals, and the chalcopyrite as small specks in the galena. The presence of the cerussite and limonite shows that some oxidation has taken place and possibly also some leaching. The workings are at no place more than 50 feet below the surface. Two samples were taken, No. 1 across 14 inches of the working face and No. 2 from the roof of the tunnel 25 feet from the entrance. These were assayed and the results are given below:

	No. 1	No. 2
Gold............	Trace	Nil
Silver...........	17·60 ozs. per ton	3·30 ozs. per ton
Lead............	19·36%	4·40%

Many other claims have been staked around the original locations, but on the majority of these only representation work has been done. On one group, however, stripping and open-cutting have shown traces of mineralization. This group lies on the summit to the west of the head of Homestead creek, and consists of three claims, the Surprise, the Enterprise, and the Hillside, owned by C. Coutts and J. McKinnon. On the Hillside claim there are two veins, both of which show float containing iron, manganese, and lead minerals. On the Surprise claim a wide band of float with the same minerals apparently shows the location of another vein. Stripping work was in progress at the time of the writer's visit, but bedrock had not been reached, and consequently it was impossible to estimate the value of these veins.

Rambler Hill Property

The Rambler hill property (Map 1937) is situated on Rambler hill, about 6 miles east of the foot of McQuesten lake. The workings lie above timber-line, at an elevation of about 5,000 feet. Eight claims are held, owned by Messrs. A. Martin, A. Lamb, A. R. Thompson, H. Colley, J. Alverson, G. Forey, J. Lake, and J. Robertson, each of whom owns an undivided eighth interest. The property is connected by a 4-mile trail to the winter road from Galena creek to mount Cameron. The workings consist of a shaft about 80 feet deep on the summit of the hill and a crosscut of 12 feet. The vein was traced down the hill for about 300 feet in elevation by means of open-cuts, and an adit has been started here.

At the time of the writer's visit (July, 1921) the shaft was full of water and the upper workings could not be examined. The data obtained from a previous examination* are given here for purposes of reference. The vein-filling consists of limonite, galena, pyrite, quartz, cerussite, anglesite (?), malachite, and chalcopyrite. Limonite makes up by far the greater mass of the deposit. Included in it are small nodules of galena, coated with oxidation products. Near the surface and extending downward for 37 feet are large masses of galena. Farther down, these disappear, leaving only the small nodules.

Galena appears in three open-cuts along the vein between the shaft and the adit. In the adit the vein is 3 to 4 feet wide. The strike and dip are both variable. The vein-filling consists of iron oxide and carbonate, manganite, and galena with lead carbonate and a little chalcopyrite. The galena occurs in small bands in the vein, and the chalcopyrite as small specks in the galena.

Two samples of the massive galena were taken. Although these do not represent the average content of the vein, they do give valuable informa-

*Cockfield, W. E., Geol. Surv., Canada, Sum. Rept., 1918, p. 6B.

tion with regard to the ratio of ounces of silver to one per cent of lead. This ratio determines whether the ores can be concentrated sufficiently to pay for shipment. The samples gave the following results:

	No. 1	No. 2
Gold	Nil	Nil
Silver	36·80 ozs. per ton	36·00 ozs. per ton
Lead	54·91%	52·60%

On claims surrounding Rambler Hill property very little, other than representation work, has been done. In some places veins have been uncovered but work has not progressed far enough to enable much data to be given. One of the most promising of these properties is the Lucknow claim owned by A. R. Thompson. This lies on the long, flat stretch of upland to the east of Rambler hill. Here a fault fissure occurs: it can be traced on the surface by means of float for more than 2,000 feet and is partly exposed in a trench that has not yet reached bedrock but which discloses part of a broken outcrop of massive galena that is, probably, almost in place. Judging from the galena the vein has a width of 6 or 7 feet and of this width the massive galena occupies, probably, about 5 feet; but until more work is done nothing definite can be ascertained about the vein.

The Homestake group on Cache creek owned by A. Martin, W. J. Elliott, Fred Arnold, and B. Verschoyle, shows several veins. There are at least two fault fissures which have float showing iron manganese and lead minerals, but until the overburden is cleared away the character and content of the veins cannot be known.

At other points on the hill, particularly on both hillsides overlooking Rambler creek, galena float has been found, but the veins from which it comes have not been located. Some of this float is reported to be richer in silver than any of the galena tested during the past summer.

Mount Cameron Property

The Mount Cameron property (Map 1940) is situated on Cameron mountain about 45 miles in a direct line northeast of Mayo, and lies near timber-line on the central fork of Alverson gulch. The winter road from Galena creek to the property has not been completed, but there is a trail from the end of it to the workings. The distance from Mayo by way of this road is about 65 miles. The property consists of three claims, Cameron No. 1, No. 2, and No. 3 owned by J. Scougale, J. Alverson, and J. Philip.

The workings consist mainly of an adit and a crosscut, but at the time of the writer's visit (August, 1921) the entrance to these was blocked by caving of the roof. There are, also, several trenches. The outcrop is a decomposed mass of iron and copper minerals, chiefly limonite, manganite, malachite, and azurite, and judging from the material which had been excavated from the adit, the chief minerals present are pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, limonite, siderite, manganite, and calcite. The galena apparently occurs in streaks and small masses in the other gangue minerals and, judging from the material on the dump, these streaks would reach a width of 6 to 8 inches. The mineralized outcrop is 50 feet wide and can be traced on the surface for 440 feet, and occasional patches of float show that the vein continues. When, however, the fault passes out of the limestone the fissure is, apparently, filled with a fault breccia composed of broken schist, apparently barren. Passing downward in the series the character of the fault is unknown, as its track is covered by forest growth.

A sample of the galena on the dump was picked so as to represent as nearly as possible the best of the material in sight. Although such a sample in no way represents the average content of the ore, it gives useful information as to the ratio of ounces of silver to one per cent lead. This assayed:

Gold	Nil
Silver	76·00 ozs. per ton
Lead	56·83%

It is manifestly impossible to make a fair estimate of the value of this property, as deductions made from the weathered outcrop are sure to be misleading. The vein is a large one—the widest noted in the Davidson mountain group—and it extends probably for 2,000 feet, but the character and extent of any ore-bodies it contains cannot be judged from the few tons of material on the dump.

Conclusions

The ores of Stand-to hill, Rambler hill, and Mount Cameron—and in fact of all the other prospects noted in Davidson mountains—are strikingly similar in mode of occurrence and mineralization. They also resemble the Keno hill ores in many ways. Keno hill is 5 miles away directly across Ladue valley from Stand-to hill. There are, however, marked differences between the Davidson mountain ores and those of Keno hill, the former being much lower in their silver content and mineralization. The Keno hill ores almost invariably show a silver content of 3 or 4 ounces to 1 per cent lead, whereas the highest obtained during the past summer from the Davidson mountain ores was 1·33 ounces to 1 per cent lead. This is due to the fact that the Keno hill ores contain freibergite, a rich copper-silver salt, whereas in the others chalcopyrite, probably carrying little or no silver, is present. The cause of this difference in mineralization is not yet apparent.

In considering these properties from an economic standpoint it must be borne in mind that the deciding factor at the present time is the cost of transportation. Under present conditions it is doubtful if ore or concentrates could be successfully shipped unless the content realized at least $100 per ton. Ore cannot be hauled 65 miles by sled and then shipped several hundred miles to a smelter unless that ore is extremely rich—a condition which the deposits in the Davidson mountains do not fulfil.

1922

Introductory Note

In 1922, the Director, W. H. Collins, includes the following note on field work in Yukon Territory in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1923, page 8:

"W. E. Cockfield commenced the geographical and geological mapping, for publication on a scale of 1 inch to 4 miles, of an area of 800 square miles around Whitehorse. The area is part of the eastern margin of the Coast batholith and includes the copper ore deposits at Whitehorse, the gold-silver deposits of Wheaton district, and various other evidences of mineralization. Two seasons of field work will be required to complete the area."

EXPLORATIONS IN SOUTHERN YUKON

by W. E. Cockfield

In reviewing the published descriptions of the mineral deposits of Whitehorse, Wheaton, and Conrad districts, it was found that wherever the genesis of these deposits has been established it is attributed to the intrusion of the Coast Range batholith. It was, consequently, considered advisable to map the eastern edge of these granitic rocks in order that prospectors might know more precisely the location of the zone, adjacent to these rocks, in which ore-bodies are likely to occur. With this in view, the writer commenced mapping such parts of the area lying between longitudes 134 and 136 degrees and latitudes 60 and 61 degrees as had not already been mapped.

Of the area assigned, considerably more than half is now completed. A reconnaissance map of this part, on the field scale of 2 miles to the inch, to show the drainage and geology, is compiled and waiting for the additional field information to complete the area. During the course of the field work the writer was ably assisted by N. T. Ellis, T. D. Guernsey, and R. H. B. Jones, all of whom performed their duties in a capable and satisfactory manner.

Topography

The area lies along the junction between Yukon plateau and the Coast Range* and contains parts of both these provinces. The Coast Range in general is an irregular complex of peaks and ridges that possess little symmetry other than a rough alignment on a northwesterly trending axis. It has everywhere a jagged and precipitous aspect, and consists of rugged or even needle-like summits, knife-edged crests, and sharply incised valleys. The summits stand at elevations of from 5,500 to 7,500 feet.

The Yukon plateau is an upland surface standing at an elevation of 5,000 to 5,500 feet. Into this surface the streams have cut to depths varying from 1,500 to 4,000 feet, giving a very irregular topography. The summits of the unreduced ridges lying between waterways are the remains of a gently rolling plain, which is broken only here and there by isolated

*For a discussion of the physiographic provinces of Yukon, *see* Cairnes, D. D., "Wheaton District", Geol. Surv., Canada, Mem. 31, 1912, pp. 9-11.

residuary masses that rise above the general level. This surface is apparently an uplifted and dissected peneplain.

General Geology

The area under discussion lies along the eastern edge of the Coast Range batholith, and practically the entire area is believed to be underlain at some depth by the granitic rocks of this batholith, isolated bodies of which outcrop at intervals to the eastward of the main boundary. In addition to these granitic rocks the area contains numerous other rock types, including igneous, sedimentary, and metamorphic varieties which range in age from the Precambrian to the Tertiary or Quaternary. In the central part of the area the plateau surface corresponds very closely with the original roof of the batholith, so that remnants of the former roof of this igneous body are still preserved. In addition there are numerous masses of the rocks invaded by the granites which remain as inclusions in the granites. Farther west these masses gradually become less numerous and disappear, having most likely been removed by erosion.

Table of Formations

Era	Period	Formation	Lithological characters
Quaternary. .	. . . .	Superficial deposits.	Gravel, sand, clay, soil, muck, volcanic ash, ground ice, slide rock, and morainic materials
		Wheaton River volcanics	Rhyolite, granite porphyry, and related volcanics with their tuffs and breccias
Tertiary.	. . . .	Chieftain Hill volcanics	Andesite, basalt, and related rocks with their associated tuffs and breccias
	Cretaceous to Jurassic	Coast Range intrusives	Granitic rocks ranging from granite to diorite with associated porphyritic phases
	Probably Lower Cretaceous	Perkins volcanics	Andesite, diabase, basalt, with associated tuffs and breccias
Mesozoic. . . .	Lower Cretaceous or Jurassic	Laberge series. . . .	Argillite, metargillite, shale, sandstone, conglomerate
	Jurassic.	Tantalus conglomerate (Kootenay?)	Conglomerate and sandstone with seams of coal
Palæozoic. . . .	Triassic to Carboniferous. . .	. . . .	Crystalline limestone
			Cherty quartzite, black slate, biotite, slate, and limestone
	Devonian?.	. . . .	Pyroxenite and peridotite
Precambrian.	. . . .	Mt. Stevens group (Yukon group?)	Sericite and chlorite schists, mashed basic and semi-basic volcanics, gneissoid quartzite, hornblende gneiss, and crystalline limestone

The oldest rocks known to occur in the area are included in the Mt. Stevens group, a series of sericite and chlorite schists, mashed basic volcanics, gneissoid quartzites, hornblende gneiss, and crystalline limestones. These represent remnants of the roof of the Coast Range batholith or inclusions in it and are really a complex of both igneous and sedimentary rocks which have suffered prolonged dynamic metamorphism. These are probably equivalent to the Yukon group* and are thought to be Precambrian in age.

More recent than the Mt. Stevens group are certain pyroxenites and peridotites which occur only on the southern part of Tally-Ho mountain. These are thought to be related to similar rocks in other parts of Yukon and in northern British Columbia, and are believed to be of Devonian age.

Outcropping along parts of Windy arm and Tagish lake is a series of sedimentary rocks; cherty quartzite, black slate, biotite slate, and limestone. They extend toward Atlin lake, and are followed by limestone, generally crystalline, from which occasional fragments of fossils are obtained. This limestone may be referred either to the Upper Carboniferous or to the Triassic.

In Mesozoic time a considerable thickness of sediments was deposited in this part of Yukon Territory, and although a large part of these have been removed by erosion, in the central part of the map-area they are still preserved, and have an aggregate thickness of from 5,000 to 6,000 feet. No complete section of these beds has been obtained. The lower conglomerate series (Tantalus conglomerate) has a thickness of about 1,000 feet and on the basis of fossil evidence is referred to the Kootenay. It is coal-bearing in the lower part. The Laberge beds consist of argillites, metargillites, shales, sandstones, arkoses, tuffaceous conglomerates, and bedded tuffs, and these have been referred to the Lower Cretaceous. Much of the material forming these beds is of igneous origin. In certain parts of the district the division into Tantalus conglomerate and Laberge series has not been carried out, as both were included in the one group, the Tutshi series, by earlier investigators.

Contemporaneous with these sediments, and possibly in part more recent than they, is a series of volcanic rocks, chiefly andesites, diabases, and basalts, with their associated tuffs and breccias.

Following the volcanics are the Coast Range intrusives, which present a number of rock types ranging from granite to diorite or gabbro. These rocks have dominantly a granitic habit, and granodiorite is the prevalent rock type. The Coast Range batholith apparently represents an igneous complex formed by a long and probably intermittent period of intrusion. Pebbles of granodiorite identical with that of the Coast Range are very numerous in the Laberge beds; yet even the uppermost of these beds are invaded by Coast Range rocks. This would point to several periods of intrusion with intervals during which sufficient time elapsed to permit of the cooling and erosion of the intrusives.

The Tertiary and Quaternary are represented by two types of volcanic rocks, the earlier consisting of andesites and basalts with their associated tuffs and breccias. Some of these flows appear to be quite recent, having been poured forth since the rivers have cut approximately to their present depths. They may consequently be Pleistocene or even Recent in age.

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*Cairnes, D. D., "Yukon-Alaska International Boundary", Geol. Surv., Canada, Mem. 67, 1914, pp. 38-44.

These are followed by rhyolites, quartz porphyries, and related rocks which occur only as dykes and small surface flows.

Overlying all the consolidated rock formations there is a mantle of superficial deposits including sand, gravel, clay, soil, muck, ground-ice, volcanic ash, slide rock, and morainal materials. This mantle covers all the valley bottoms and in addition extends over large parts of the valley walls and upland surface.

Economic Geology

The mineral deposits of the Conrad, Whitehorse, and Wheaton districts have in large part already been described*. Briefly stated, the mineral resources, excluding coal, may be grouped into four classes as follows:

I. Contact metamorphic deposits. Chiefly copper.
II. Gold-silver deposits.
III. Silver-lead deposits.
IV. Antimony-silver deposits.

Contact Metamorphic Deposits

The contact metamorphic deposits include all the properties of the Whitehorse copper belt, and also the Fleming mineral claim on Carbon hill, Wheaton district. These deposits, in the first case, occur in altered limestones close to, or in direct contact with, the Coast Range granodiorites; and in the second case, in hornblende gneiss at the contact with the same intrusives. There can be no doubt as to the close genetic connexion between the ore-bodies and the intrusion of the Coast Range batholith, this being apparent on even the most casual examination.

Gold-Silver Deposits

The gold-silver deposits include the properties on Stevens, Wheaton, and Tally-Ho mountains, Gold hill, Becker creek, and the Big Thing mine on Windy arm, all of which have been described**, and also the Midnight group to be described later. Discussing the genesis of these deposits Cairnes says in part: "It is, therefore, apparent that if these deposits are associated with any of the igneous materials of the district, these must be the Jurassic granitic rocks. In the field the veins appear to be everywhere intimately associated with these intrusives so that the genetic relationship between them appears certain." The majority of these veins occur in a belt 2 to 3 miles wide closely paralleling the eastern boundary of the Coast Range batholith.

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*McConnell, R. G., "Whitehorse Copper Deposits", Geol. Surv., Canada, Sum. Rept., 1900, pp. 49A-52A, and "Windy Arm District", Geol. Surv., Canada, Sum. Rept., 1905, pp. 30-32.

Cairnes, D. D., "Explorations in a Portion of Yukon south of Whitehorse", Sum. Rept., Geol. Surv., Canada, 1906, pp. 24-30, and "Report on a Portion of Conrad and Whitehorse Mining Districts, Yukon", Geol. Surv., Canada, pp. 13-23.

McConnell, R. G., "Report on the Whitehorse Copper Belt", Geol. Surv., Canada, 1909.

Cairnes, D. D., "Wheaton River District", Geol. Surv., Canada, Sum. Rept., 1909, pp. 51-57, and "Wheaton District, Yukon Territory", Geol. Surv., Canada, Mem. 31, 1912, pp. 85-147.

"Wheaton District", Geol. Surv., Canada, Sum. Rept., 1915, pp. 43-49.

**Cairnes, D. D., "Wheaton District", Geol. Surv., Canada, Mem. 31, 1912, pp. 87-113. Geol. Surv., Canada, Sum. Rept., 1917, p. 36.

Silver-Lead Veins

The principal silver-lead properties which have been described are the Union and Nevada mines, Wheaton district[1], and the Montana, M and M, Venus, and Dail Fleming group of Windy Arm district[2]. The Mascot group is described in this report. The genesis of these deposits appears to be somewhat uncertain. They have been attributed to igneous rocks of different ages, but the probability seems to be that they owe their origin to the phenomena attending the latest stages of the intrusion and cooling of the batholith.

Antimony-Silver Deposits

The most important of the antimony-silver claims are the Porter group and Goddell group on Carbon hill, and the Morning claim and Evening claim on Chieftain hill. These have all been described[3] and their origin is ascribed to heated waters ascending from the cooling mass of the Coast Range batholith.

This review will serve to show the importance of the Coast Range batholith in connexion with the ore deposits of the district. It may also be pointed out that the majority of the ore-bodies occur in connexion with outlying bodies of granite rather than with the main mass of the batholith, although there are many exceptions. It may also be laid down as a general rule that the main mass of the batholith away from its borders is not likely to have been the seat of ore deposition, except possibly where there are inclusions of the older intruded rocks.

Only three properties were visited by the writer during the past summer. These included both gold-silver and silver-lead veins. The silver-lead vein visited lies on the Mascot group at the head of a small tributary to Watson river. The vein occurs practically on the divide between Berney creek and Watson river. The property is owned by E. Johnson and M. Watson of Carcross, but was bonded to J. Moore Elmer of the Slate Creek Mining Company during the winter of 1921-22. A small amount of prospecting was done on the claims, but the option was abandoned in the spring of 1922.

The outcrop is visible along a cliff face for about 2,000 feet. The vein varies considerably in strike, dip, and thickness, being in some places 20 feet thick and in others less than 1 foot. At the foot of the cliff an adit was driven 200 feet on the vein. It was filled with water and ice at the time of the writer's visit, and consequently only the surface features could be examined. According to information supplied by J. M. Elmer the vein pinched to 6 inches towards the end of the tunnel and the values dropped to $7 a ton in gold and silver. Assays from the outcrop, it is claimed, show values of from $15 to $30 a ton in gold and silver. Below the mouth of the adit the vein is 6 feet wide, but it narrows to less than 2 feet inside the portal. The country rock is a diorite (Coast Range intrusives) and near the deposit is a large inclusion of schist (Mt. Stevens group). The writer took a grab sample across the 6-foot width of the vein immediately below the entrance to the adit. This was assayed and found to contain:

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[1]Cairnes, D. D., "Wheaton District", Geol. Surv., Canada, Mem. 31, 1912, pp. 129-139.

[2]Cairnes, D. D., "Report on a Portion of Conrad and Whitehorse Mining Districts, Yukon", Geol. Surv., Canada, 1908, pp. 14-18.

Sum. Rept., Geol. Surv., Canada, 1917, pp. 36-44.

[3]Cairnes, D. D., "Wheaton District", Geol. Surv., Canada, Mem. 31, 1912, pp. 113-129.

Gold	0·11 oz. per ton
Silver	1·45 "
Lead	(not determined)

Though the results obtained so far from the prospecting of this property have been unsatisfactory it must be remembered that only a small part of the vein has been explored by underground workings, and these workings do not extend under the widest parts of the vein as shown on the surface. The possibility of finding paying ore-shoots on the property has not been exhausted.

The deposit is somewhat unfortunately situated with regard to transportation. There is no road to the property, and the nearest point on the railway is Robinson, about 45 miles distant. A road could easily be constructed up Watson river to the property, or from the end of Wheaton River wagon road at Carbon hill up Berney creek, but in either case the distance to the railway would be about the same.

Midnight Group

The Midnight group is situated on Midnight gulch, a tributary to Wheaton river, about 8 miles above its mouth. The property is readily accessible from Carcross by a boat across lake Bennett to the mouth of Wheaton river, whence a trail leads to the claims.

The Midnight group consists of six claims, the Midnight, Midnight No. 1, Midnight No. 2, Anna Frances, Guardsman, and Harrison, owned by Matthew Watson and E. Johnson, of Carcross.

The workings consist of three short adits and a large number of open-pits or trenches. Two of these adits are situated close to the camp on the Midnight No. 1. The third is situated on the Midnight No. 2 near the crest of the hill and is known as the 'old showing'. In addition there are a number of open-pits situated on the Midnight, Midnight No. 1, and Midnight No. 2.

The showings are all very similar in character so that only typical ones need be described. On the Midnight claim there is some trenching known as the 'lower workings'. Here a dyke of granite porphyry is shown cutting schists of the Mt. Stevens group, and the dyke itself contains some inclusions of schist. Close to the hanging-wall of this dyke is a small dyke of basalt that cuts the granite porphyry, and, near the foot-wall, another dyke 7 feet wide of the same material. The width of the granite porphyry dyke is 50 feet. The granite porphyry is very much altered and, apparently, silicified. Under the microscope it shows large crystals of feldspar in a micrograniic groundmass. The feldspar is highly altered to sericite. Running through both the feldspar crystals and the groundmass of the rock are small veins of quartz which are taken to represent secondary silicification. The infiltration of secondary silica was probably accompanied by deposition of the ore minerals, pyrite, galena, and occasional specks of native gold visible to the naked eye. The gold occurs both with the sulphides and also in the quartz when the sulphides are absent.

There is a similar occurrence at the 'old showing' on the Midnight No. 2 claim. Here a dyke of granite porphyry 25 feet wide cuts the Perkins volcanics. The dyke is well silicified and carries seams of quartz containing pyrite, galena, and free gold. The two adits situated near the camp show, apparently, two-cross seams, but these are not well exposed. Both of the seams are considerably leached and decomposed. Colours of gold may be obtained by panning this material.

Adjoining the Midnight group are a number of claims, but on only two of these, the Gladys S and Sarah J, owned by T. Brooks, has any work been done. The occurrences here are similar to those already described.

These porphyry dykes have been traced for considerable distances by means of surface pits and trenches. They are, apparently, broken by a series of more or less parallel cross-faults, which would require further stripping and an accurate survey of the property to work out. There would, however, be no question of the tonnage available if it could be demonstrated that the values were persistent over the width of the dykes. A rough sampling of the property indicates, however, that the values in gold are not maintained over the mass of the dykes, even where silicification is complete, but are confined to small portions where either gold or sulphides are visible. These portions form only a very inconsiderable part of the whole deposit. It, therefore, remains to be demonstrated whether these portions carry sufficient values to form ore-shoots. This can be done only by further stripping and systematic sampling. The writer is inclined to regard those points where cross-faults or cross-seams intersect the main dykes as the most probable locations of ore-shoots.

The second gold-silver property visited lies on the eastern slope of mount Reid, near the junction of Berney creek and Wheaton river. The property is situated about 5 miles beyond the end of Wheaton wagon road, or 36 miles from Robinson. There are two claims, the Grandview owned by A. Birnie, and the Rambler by C. I. Burnside.

The vein is situated in a small gulch tributary to Skookum gulch, and the workings consist of a number of trenches. At the time of the writer's visit the gulch was largely filled with snow so that very little could be seen of the deposit. The country rock consists of the Perkins andesites, which at this point form an inclusion in the Coast Range granodiorites. The vein is first exposed on the shoulder of the mountain near the top of the small gulch. About 500 feet below this is a small opencut in which the vein is partly exposed. At the upper workings the surface trench has been filled in with slide rock. The lower workings, however, show a vein 3 feet in width with gouge on either side. The vein at this point is almost vertical. Mineralization consists of galena, pyrite, stibnite, and arsenopyrite in a gangue of quartz. The vein has been exposed on the surface over a distance of 1,000 feet by means of pits, but most of these were filled with slide rock.

Coal

Coal is known to occur at several localities in the area under discussion. Seams occurring on Coal creek near Dugdale and Idaho hill have already been described*. The coal occurs in the Jura-Cretaceous Tantalus conglomerates, in or immediately below which have been found all the valuable coal so far discovered in southern Yukon. It is quite probable that other seams exist in addition to those described by Cairnes. There is, however, at present no demand for coal in southern Yukon, and prospecting for it is consequently not being carried on.

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*Cairnes, D. D., "Report on a Portion of the Conrad and Whitehorse Mining Districts, Yukon", Geol. Surv., Canada, 1908, pp. 20-21, and "Wheaton District", Geol. Surv., Canada, Mem. 31, 1912, pp. 145-147.

1923

Introductory Note

In 1923, W. H. Collins, Director, refers to field work in Yukon Territory in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1924, page 9, as follows:

"W. E. Cockfield spent part of the field season in an investigation of the ore deposits of Keno Hill area, Mayo district. A brief examination was also made of the newly discovered silver-lead deposits of Beaver River area, about 80 miles northwest of Mayo. Reports on these investigations are published in the Summary Report of the Geological Survey for 1923, Part A. The geographical and geological mapping of the area around Whitehorse in southern Yukon, begun in 1922, was also carried on. During Cockfield's absence in northern Yukon the work in the southern part was continued by A. H. Bell. A small part of the work in this area remains unfinished."

At the end of the Summary Report for 1923, Part A, page 102, the Director includes the following paragraph under the heading "Other Field Work":

"*W. E. Cockfield and A. H. Bell.* Bell continued the geographical and geological mapping of a 4,500 square-mile sheet in southern Yukon lying between latitudes 60 degrees and 61 degrees and longitudes 134 degrees and 136 degrees, which was begun in 1922 by Cockfield. This sheet, when completed, will include Conrad, Whitehorse and Wheaton districts, which form part of the eastern margin of the Coast batholith and which contain important silver, gold, and copper deposits and other evidences of mineralization. The western half of the sheet was completed in 1922, but there still remains unfinished a small part of the eastern half. The results of the investigation will be published as a memoir, accompanied by a map on a scale of 1 inch to 4 miles, now in course of preparation."

GEOLOGY AND ORE DEPOSITS OF KENO HILL, MAYO DISTRICT

by W. E. Cockfield

Silver-lead ore deposits were discovered at Keno hill in July, 1919, by L. Beauvette. Almost immediately the Yukon Gold Company, Limited, secured options of purchase on the original claims, and as a result a stampede to the hill took place. Over 500 claims were located in the next few months and this number has since been very materially increased. During the winter of 1919-20 the Yukon Gold Company prospected their holdings and secured options on a number of other claims. In 1920, a subsidiary company, Keno Hill, Limited, was formed to operate the original group, and the entire holdings of the parent company have since been turned over to this subsidiary.

Ore shipments from Keno hill commenced during the winter of 1920-21, and the tonnage shipped has increased in each succeeding winter. In 1921, the Sadie-Friendship vein was discovered and has since proved of such importance that its production will soon surpass that of the original discovery. The Yukon Gold Company acquired the Sadie and Friendship claims and the Treadwell Yukon Company, Limited, secured a group of claims on the northern extension of the same vein. A third company, Onek Mining Company, Limited, also entered the field in 1921, securing options on a number of claims scattered over the hill; but in 1922 this company suspended operations, and has not since renewed them.

The writer wishes to express his thanks for the many favours and courtesies received while engaged on the examination of the deposits. Particular thanks are due to Messrs. Livingston Wernecke and W. B. Hargreaves, of Treadwell Yukon Company, and to Messrs. F. R. Short and A. K. Schellinger, of Keno Hill, Limited, for information without which the compilation of this report would have been impossible.

A. H. Bell, C. H. Stockwell, C. S. Evans, and H. T. Ellis acted as assistants.

Location

Mayo is situated 180 miles up Stewart river, one of the main tributaries of Yukon river, which it enters 72 miles above Dawson. Mayo serves as a business centre for the surrounding district to which it gives its name. From June until October the White Pass and Yukon Route maintains a regular steamer service on Yukon and Stewart rivers, in connexion with their railway service from the coast to Whitehorse. In winter, Mayo can be reached by mail stage either from Whitehorse or Dawson.

Keno hill is 40 miles northeast of Mayo. A good wagon road to it has been constructed by the Yukon government from Mayo and the journey may be made in a few hours by automobile. Telephone communication has been established between the mines and Mayo, and the Federal government has recently established wireless stations at Mayo and Dawson, thus connecting Mayo with outside points by means of the Yukon Telegraph line.

Hitherto, practically all haulage in Mayo district has been done by horse-drawn vehicles, chiefly in the winter time, when the roads were at their best. During the winter of 1922-23, however, the Treadwell Yukon Company introduced caterpillar tractors and reduced the cost of haulage about two-thirds. As the previous cost of hauling ore to Mayo had been nearly half the cost of shipping from mine to smelter, the saving is important.

Topography

Mayo district lies within Yukon plateau. The hills are prevailingly flat-topped and separated by broad, deep valleys. Keno hill is a typical wedge-shaped ridge, lying between Lightning, Christal, Faith, and Ladue creeks. It is 10 miles long by 6 miles wide at the western end, tapering to the east, and is surmounted by five hillocks locally known as Keno, Minto, Monument, Caribou, and Beauvette, which rise a few hundred feet above the general level. The northern slope of the hill is steep, but is broken by a series of benches, representing the outcrops of harder formations. The southern slope is more gentle, being controlled to some extent by the dip of the strata.

General Geology

The greater part of Mayo district is underlain by schists, which are intruded by sills and laccoliths of greenstone, and by dykes and sills of granite porphyry and quartz porphyry. Keno hill lies within this schist belt, and consequently the rocks outcropping are those enumerated above.

The schist series consists of quartzite, quartz-mica schist, graphite schist, sericite and chlorite schist. The greenstones intruding this schist series are themselves largely sheared and altered. The quartz and granite porphyries are massive and fresh in appearance and are believed to be offshoots from a granite mass which outcrops some miles to the east, and which probably extends under a considerable part of Mayo district.

The quartzite, quartz-mica schist, and graphite schist are believed to belong to the Nasina series, described by McConnell in his report on Klondike district. This series has been referred by Cairnes to the Precambrian. In the type sections the rocks consist of alternating bands of blue and white, thinly laminated quartzites, that pass gradually into dark grey quartz-mica schists, and finally into black, graphite schists. In the Keno Hill area, however, the quartzites as a rule are more blocky and homogeneous than is the case in Klondike region. Under the microscope the minerals present are seen to be the same in all cases, but to vary in abundance according to the type of rock. Quartz, the most abundant constituent, appears as a fine mosaic of grains, in some cases highly granulated, in others with sutured texture showing recrystallization. A subordinate amount of feldspar is associated with the quartz. The micas, biotite, and sericite are arranged in parallel bands, or sweep in a series of waves through the granulated mass of quartz and feldspar. Chlorite, calcite, magnetite, pyrite, and graphite are also present, the last named becoming locally abundant enough to form a graphite schist. In many cases, however, graphite is most abundant along the planes of schistosity. This series represents a great thickness of siliceous and argillaceous sediments now altered into quartzites, quartz-mica, and graphite schists.

The sericite and chlorite schists are present only in minor amounts. The sericite schist has been recognized only on the first and third levels of Treadwell Yukon Company's workings, where it is intrusive into the quartzites, and the chlorite schist on the Lake group. Under the microscope these rocks were seen to consist mainly of varying amounts of quartz and feldspar, sericite, and chlorite, with numerous accessory and secondary constituents. All the specimens examined are fine grained and highly altered. These rocks are believed to be similar to McConnell's Klondike series, which consists of altered acid and intermediate volcanics.

The rocks included under the field name of greenstone occur as sills and laccoliths throughout the area. They are frequently sheared and altered, and now consist of secondary minerals to such an extent that it is difficult to determine their original composition. They are dense, green, medium-grained to aphanitic rocks. In spite of their alteration they are more resistant than the schistose rocks, and consequently project above the surrounding surface. Microscopically, the rocks are seen to consist largely of hornblende, or augite and feldspar. In some of the specimens examined the hornblende was quite fresh, but most of it is altered to chlorite. Calcite is also a common secondary constituent. The commoner variety is porphyritic, and in this type the alteration to secondary minerals is as a rule complete. The coarser-grained varieties are hornblende diorites and augite diorites.

The quartz and granite porphyries occur as dykes and thin sills. They are light-coloured to white rocks of massive appearance, showing crystals of quartz and feldspar. An important feature of these rocks is that they contain particles of the minerals of the ore-bodies, such as pyrite, galena, and occasionally tetrahedrite. These are commonest along joint-planes, but occur, also, in the body of the rock. The phenocrysts consist of corroded quartz and orthoclase in a microfelsitic to microgranitic groundmass of quartz, feldspar, and muscovite.

The greater part of the surface of Keno hill area is covered with soil, talus, muck, boulder-clay, and vegetation. Rock outcrops are not numerous and these belong chiefly to the harder formations, such as quartzite and greenstone. The covering of superficial deposits renders prospecting difficult, as it is commonly frozen down to bedrock, and the thawing in summer is relatively shallow. Much prospecting has been done in the past by using snow water in the spring for ground-sluicing. It is possible that further discoveries will be made on Keno hill as more prospecting is done, either of new veins, or along the extension of veins already known to exist.

Ore Deposits

The ore deposits of Keno hill area are practically all fissure veins, that is, they represent vein material deposited in fault fissures. The faults which gave rise to these veins are all of the normal type, and this applies also to post-mineral faults. No reverse faults have been recognized. The displacement is as a rule small and the maximum horizontal displacement noted is 500 feet.

The veins may be divided into two classes, which in an earlier report* were termed longitudinal and transverse, depending on whether they follow the trend of the strata or cut across the strata. These two fault systems represent two stages of mineralization, the longitudinal faults being the earlier. In general, these strike north 30 to 40 degrees east magnetic, and the transverse faults make an angle of 70 to 80 degrees with them. There is, however, considerable variation in direction of the faults in different parts of the area, and mineralization rather than direction is the criterion to determine to which class a vein belongs.

The strata in the area have a general east-west trend, but near the hillock known as Monument hill the beds bend sharply to the south and continue southward across Lightning creek where they gradually resume their former direction. It is believed that the transverse faulting is directly attributable to this flexure, owing to the bending of resistant beds such as quartzite and greenstone. The origin of the longitudinal faults has not been satisfactorily solved; they may, however, be due to stresses developed at the time of intrusion of the granite mass referred to before.

The earlier mineralization consists of quartz, arsenopyrite, and pyrite. After being filled, the longitudinal fissures remained planes of weakness affected by subsequent movements. When the transverse fissures were mineralized, they probably acted as the main circulation channels for the ore-bearing solutions and considerable amounts of the ore minerals were deposited in them. The chief minerals of the second stage are siderite, freibergite, galena, and sphalerite.

Production

The following table gives the total production of Keno hill, and estimated values of silver and lead. Tonnage figures are those published by the

*Cockfield, W. E., Geol. Surv., Canada, Sum. Rept., 1920, pt. A, pp. 3-4.

collector of customs, Dawson; the values are estimated, as in some cases the smelter returns are not available. It is expected that the output for 1923-24 will equal that of 1922-23.

Production and Estimated Values of Silver and Lead from Keno Hill

Year	Tons	Value silver	Value lead	Total value
		$	$	$
1920-21	2,102	218,395	100,900	319,295
1921-22	3,231	471,320	197,770	669,000
1922-23	7,982	1,056,902	379,253	1,436,155
Totals	13,315	1,746,527	677,923	2,424,450

Mineralogy of Ore Deposits

The following ore and gangue minerals have been identified from the Keno Hill deposits.

Native elements. . .Silver
Sulphides. . . . . Argentite, galena, sphalerite, covellite, chalcopyrite, pyrite, arsenopyrite
Sulpho-salts. . . . . . Pyrargyrite, freibergite, polybasite, jamesonite
Oxides. . . . . Quartz, limonite, manganite
Carbonates. . . . . . . Siderite, calcite, cerussite, malachite, azurite
Sulphates. . . . . Barite

Native Silver (Ag) is uncommon. It has been noted as small microscopic grains enclosed in masses of cerussite. It is of local occurrence and not disseminated through the deposits.

Argentite (Ag_2S) is uncommon. It has been noted as small microscopic crystals occurring with galena.

Galena (PbS) is one of the most important minerals and was found in every deposit examined. It is commonly coarsely-crystalline and not intimately intergrown with the other ore or gangue minerals. The coarse galena has a gneissoid appearance. The fine-grained, steel galena is somewhat rare, but carries average values in silver.

Sphalerite (ZnS) occurs in most of the deposits. It is yellowish brown and resinous in appearance.

Covellite (CuS) is very rare. A few small particles were noted in ore from No. 9 vein, Keno Hill, Limited.

Chalcopyrite ($CuFeS_2$) is not common and where found is as a rule intimately associated with galena.

Pyrite (FeS_2) is fairly abundant, occurring both with arsenopyrite and with galena.

Arsenopyrite (FeAsS) occurs with quartz and pyrite in veins of the older series.

Pyrargyrite or ruby silver (Ag_3SbS_3) is rare. It occurs with freibergite and galena, and was noted only in a few of the deposits, where it is of local occurrence and not disseminated through the deposit. It is believed to be secondary in origin.

Freibergite ($(CuAg)_8 Sb_2S_7$) is common and is one of the chief silver minerals of the area. Where this mineral is present even in small quantities the silver content of the ore is increased. It is associated with siderite, galena, and sphalerite.

Polybasite (Ag_9SbS_6) is rare and was noted only in the microscopic study of specimens from the Gold Queen. It is believed to be secondary.

Jamesonite ($2PbS, Sb_2S_3$) is rare, but was noted in several veins on the top and southern slope of the hill. This mineral may possibly belong to the quartz-arsenopyrite stage of mineralization.

Quartz (SiO_2) is common as a gangue mineral, particularly in veins of the earlier mineralization, though not confined to these. It is rarely coarsely crystalline.

Limonite ($2Fe_2O_3, 3H_2O$) and *Manganite* (Mn_2O_3, H_2O) are abundant in the oxidized material at the surface of the deposits. The latter is believed to be derived from the siderite, and the black 'manganese' stain is a common, and as a rule a good indication of a vein lying not far beneath, and has been used in tracing some of the veins.

Siderite ($FeCO_3$), or its equivalent mangano-siderite ($(MnFe) CO_3$), is the most abundant gangue mineral of the deposits. Near the surface it is black to dark brown in colour, but with depth invariably changes to white or light brown. It is mostly fine in grain, but many coarsely-crystalline masses were noted. Siderite is nearly always accompanied by freibergite, galena, and sphalerite.

Calcite ($CaCO_3$) is not common as a gangue mineral and is mostly associated with siderite.

Cerussite ($PbCO_3$) is not common and is confined to within a few feet of the surface. It occurs as a rule in white, earthy masses.

Malachite ($CuCO_3Cu(OH)_2$) and *Azurite* ($2CuCO_3Cu(OH)_2$) occur as oxidation products only at the surface.

Barite ($BaSO_4$) is rare as a gangue mineral, having been noted at a few points only.

Location of Ore-Shoots

In a former report the rule was enunciated that where a transverse vein intersects a longitudinal vein and passes upward from a hard rock such as quartzite or greenstone, into schist, the vein below the schist is an extremely favourable location for the formation of an ore-shoot. This is most probably due to the fact that the fissure through the harder rocks remained relatively open to the ore-bearing solutions, whereas in the schist the fault was more or less sealed by a clayey impervious gouge, forming a dam which forced deposition below it. This rule, though not absolute, has been proven in practice; the ore-shoot on No. 9 vein, Keno Hill, Limited, and on No. 3 vein of the same company, may be cited as examples. It cannot, however, be affirmed that the schist is always barren of ore, for ore-bodies are known to occur in it; but the rule given will be found to apply in a majority of cases to the transverse veins.

In the longitudinal veins, the causes of localization of ore-shoots are not so well understood, but in many cases the occurrence of black graphite schist along either wall of the fault is accompanied by ore.

Genesis

By far the greater number of veins on Keno hill represent a simple filling of fault fissures. Replacement of wall-rock operated only to a slight extent, except in the Sadie-Treadwell vein. The ore minerals in most cases are fastened to the polished walls of the fault fissures, but do not project into them. It is not believed, however, that at the time of mineralization the faults existed as open fissures 4 to 6, or more, feet wide, but rather that the small openings formed by the faults grew in width as the ore minerals were deposited. It has been demonstrated that the force exerted by a crystal in growing is equal to that required to crush it when formed*. Whether this force was active, or whether the force exerted by the mineralizing solutions was sufficient to open the fissures, is unknown.

In certain cases there is evidence of solution of the wall-rock. This is shown in No. 9 vein of Keno Hill, Limited, where large, drusy cavities lined with crystals of siderite and galena occur in the foot-wall. Replacement of wall-rock occurs in the Sadie-Treadwell vein, which presents many characters not exhibited in the other veins of the area. This vein, or rather 'mineral zone', follows an old line of weakness represented by quartz-arsenopyrite veins. It was probably re-opened by a fault which branches frequently and reunites, with cross-faults between the main fractures. The country rock in the vicinity was badly shattered and the jointing emphasized, and the ore-bearing solutions penetrated each minute crack, widening it, and, in places, replacing the country rock. In places the mineral zone is a network of tiny veinlets of siderite enclosing fragments of country rock. As a rule these fragments lie in their original positions, but in certain instances the particles of rock were rotated. These veinlets represent on a small scale what has taken place on a large scale. Veins of ore project out into the country rock, in many cases at right angles to the main trend of the ore zone. Examination of thin sections has shown that these veins grew by replacement of the country rock. Fragments of quartzite or residual masses of granulated quartz and feldspar are included in siderite. In some cases, also, individual grains of quartz are seen with siderite projecting into them. It is consequently believed that the Sadie-Treadwell ore zone represents a fault complex along which the deposit grew by widening of fissures as the minerals were deposited, and by replacement.

Source of Mineralizing Solutions

The veins in Keno Hill area traverse quartzite schists and greenstone alike. The greenstones must, therefore, have been consolidated sufficiently to permit of fracturing at or before the time of mineralization. Moreover, the greenstone bodies by reason of their small size would be unlikely to hold solutions for long periods, particularly after the development of the faults. The acid dyke rocks carry small amounts of galena, pyrite, and tetrahedrite. As these were not injected until long after the greenstones were consolidated, and even sheared, it is doubtful if the greenstones had any effect on their mineralization.

The presence of certain of the ore minerals in the quartz and granite porphyries suggests that these rocks may have been the source of the ore deposits. It is not thought, however, that these small bodies of acid intrusives caused the extensive mineralization of Keno hill, but rather that they and the mineralizing solutions had their origin in a larger body of magma. A large mass of granite occurs to the east of Keno hill, and other masses occur along a line running northwest and southeast. It is probable that these represent the peaks of a batholith which extends under much of

*Becker, G. F., and Daly, A. L., "The Linear Force of Growing Crystals", *Wash. Acad. Sci. Proc.*, vol. 7, 1905, pp. 283-288.

Mayo area. The age of these granites has not been closely determined, owing to the lack of sedimentary rocks. They have usually been considered contemporaneous with the Coast Range intrusives which in Yukon range from Jurassic to Upper Cretaceous. The ore deposits are younger, but cannot be placed more definitely with regard to age.

Secondary Enrichment

The term primary is here applied to deposits which have not been changed in chemical or mineralogical composition by superficial agencies; and secondary to deposits formed by the action of superficial agencies on primary ores. The evidence as to primary or secondary origin may be divided into two main heads: (*a*) geological, (*b*) mineralogical and textural.

Geological Evidence

In northern latitudes large bodies of secondary ores are not common, as low temperatures retard chemical activity, and freezing prevents solution. Climates have, however, undergone great changes in geologic times, and it does not follow because the processes of weathering are now inactive in any district that they have always been so. Deposits of secondary origin are, however, rare in Canada and Alaska, though there are important exceptions such as the St. Eugene mine[1], and the Premier and Dolly Varden[2]. In Yukon, a zone of permanent frost extends practically from the surface down to varying depths. The workings of Keno Hill, Limited, on No. 9 vein, at a depth of 400 feet were still in frost; on the other hand Treadwell Yukon Company reached unfrozen ground between the 200- and 300-foot levels. This frozen zone forms an exceptional barrier to the processes of weathering and as it is believed to date back to the Pleistocene[3], it follows that any secondary deposits must antedate glaciation, with the likelihood of their removal by glacial erosion. In considering the geological evidence it is, therefore, well to deal with those deposits where the workings exhibit the greatest vertical section of ore. These may be considered under two types, the massive galena deposits as examplified by No. 9 vein, and the galena-siderite-freibergite type, of which Treadwell Yukon Company's vein may be considered typical.

The rapid exhaustion of rich shipping ore in No. 9 vein might at first sight seem to imply secondary enrichment. However, the location of the ore-shoots is controlled by a bed of schist near the present surface that acted as a dam to the mineralizing solutions, and the maximum load was deposited in the fissure close to the dam. Continuing downward is a body of disseminated ore. The drop in values is largely due to inclusion of crushed country rock and gangue minerals in the vein, both of which occur sparingly in the upper workings. Assays of clean galena from the lower workings show nearly as high a silver content as that from the upper workings. In the second place post mineral fractures, though rare, do occur in this vein, but there is no evidence of circulation along such channels, which must have

[1]Schofield, S. J., Geol. Surv., Canada, Sum. Rept., 1911, pp. 158-164. Econ. Geol., vol. 7, pp. 351-363, 1912.

[2]Schofield, S. J., and Hanson, G., Geol. Surv., Canada, Mem. 132, 1922, pp. 39-42. Hanson, G., *Can. Min. Inst. Bull.*, Aug., 1922, pp. 892-895.

[3]Tyrrell, J. B., "The Frozen Muck of the Klondike district", *Trans. Roy. Soc., Can.*, vol. XI, ser. III, sec. IV, 1917, pp. 39-46.

been good conduits for downward-moving waters, and no evidence of enrichment in their vicinity.

In the Treadwell Yukon vein, the controlling factors of deposition have not yet been recognized. Consequently the relationship of this deposit to the present surface is not so well understood. It has suffered from intense post-mineral faulting, both longitudinal and transverse to the ore-body, which is cut up into a series of fault blocks. These faults would serve as excellent channels for downward-circulating waters, and along them one would expect to find secondary deposition if any is present, but there is no sign of any.

Mineralogical and Textural Evidence

The important minerals of the Keno Hill deposits are galena, freibergite, siderite, and zinc blende. These are usually considered to be primary minerals. Emmons states that galena is primary[1] and siderite usually so. Of the latter he says[2] "siderite........ is found in the gangue of deposits formed at moderate depths by hot ascending water. High temperatures are not necessary for its genesis, however, for it is most abundant in cherty iron carbonate ores of sedimentary origin. In lode deposits siderite is in the main primary." Although certain instances of secondary tetrahedrite have been cited[3], this mineral is in the main primary. Neither tetrahedrite nor the argentiferous variety, freibergite, has been formed synthetically under conditions that prevail in the secondary sulphide zone. Zinc blende may also be assumed to be primary in the absence of definite proof to the contrary.

Native silver, pyrargyrite, covellite, and polybasite have been found and these are all deemed secondary. Native silver occurs in vugs in the galena, and pyrargyrite as small specks probably as an alteration of freibergite. Instances of both pyrargyrite and polybasite in veinlets cutting freibergite were seen. All these secondary minerals, however, are in such small quantities that prolonged search is necessary even to secure specimens. With the exception of the instances noted, none of the common textures of secondary deposits is developed. The geological evidence and the mineralogical composition of the main ore-bodies, therefore, both point to a primary origin, and the writer is of the opinion that secondary enrichment played a relatively minor role in the formation of the deposits. From a study of the deposits, and comparisons with deposits in other districts, it is believed that they were formed at moderate depths by hot ascending solutions; that the mineralizing solutions had their origin in the magma that gave rise to the acid dykes and sills; and that changes in the ores with depth will depend upon changes in primary deposition. The deposits resemble in many ways the ores of the Slocan[4] district of British Columbia, and in some points also resemble those of Wood River district[5] of Idaho, though the resemblance to these is not so striking.

Silver Values

In large shipments of ore the silver has proved to be remarkably uniformly distributed through galena when free from gangue. The shipments

[1] Emmons, W. H., "The Enrichment of Ore Deposits", U.S.G.S. Bull. 625, 1917, p. 359.
[2] Emmons, W. H., op. cit., p. 454.
[3] Emmons, W. H., op. cit., pp. 278-280.
[4] LeRoy, O. E., Geol. Surv., Canada, Sum. Rept., 1919, pp. 131-133. Ingalls, W. R., Rept. of the Zinc Commission, Ottawa, 1906, p. 238. Carlyle, W. A., Bull. No. 3, Bur. of Mines, Victoria, B.C.
[5] Lindgren, W., U.S. Geol. Surv., 20th Ann. Rept., pt. 3, pp. 218-231.

already made from Keno hill average very close to 200 ounces to the ton, and this may be taken as the average silver content of galena on the hill. It has been demonstrated* that silver may exist in galena in the form of sub-microscopic particles or in solid solution only up to 0·2 per cent. Under the microscope the Keno Hill galena shows crystals of argentite and freibergite intergrown with the galena.

Description of Properties

Over a thousand claims have been staked in the vicinity of Keno hill, so that it is manifestly impossible in this report to describe every property. Certain claims or groups of claims which contain good representatives of the different types of veins on the hill have, therefore, been selected for description, especially those on which the amount of work done affords more information or which have thrown light on the genesis and mode of occurrence of the ore-bodies. There are properties not described on which veins have been located, and which future development may prove to be fully as important as some of the properties described.

Keno Hill, Limited

Original Group. Keno Hill, Limited, was organized in 1920 to work certain claims then held by Yukon Gold Company. The original property consisted of seven claims: Roulette, Keno, Scotty, Solo No. 2, Pinochle, Wolverine, and Reco; and a number of fractions. These claims are staked across the top of the ridge and extend into Faro gulch on one side and Charity gulch on the other. Frame buildings have been erected near the summit of the hill, and a power-line, 4 miles long, connects the property with a 100 K.W. steam-power plant on Duncan creek.

The principal veins of the original group consist of two longitudinal veins, No. 1 and No. 6, and a number of transverse veins. No. 9 has been the principal producing vein, although Nos. 1, 3, 4, 5, and 12 have each contributed a small tonnage. There are adits on each of these productive veins. On vein No. 3 a shaft has been sunk to a depth of 150 feet, with levels at 30, 75, and 150 feet. The first level is 140 feet long. It reaches the surface on the steep slope of Faro gulch and forms an adit. The second level is 180 feet long, and is connected with the first by a winze with an intermediate level. This winze also connects the second and third levels. Five small ore-shoots were encountered in these workings. The only one of considerable size extended from the surface down slightly below the first level. It was 40 feet long and pitched to the south, following the zone where the vein fissure has schist on both hanging and foot-wall. Other smaller ore-shoots occurred near the entrance of the adit, and near the junction of the shaft and second level. The balance of the ore found in these workings consisted of small stringers.

Vein No. 9 has produced 8,000 tons of high-grade shipping ore, averaging close to 200 ounces of silver to the ton. It will be noted that the ore is confined to the zone where the vein fissure has schist on both hanging and foot-wall. The development work is shown in the figure and need not be described. With the exception of small stringers, practically no ore of

*Nissen, A. E., and Hoyt, S. L., "Silver in Argentiferous Galena", Econ. Geol., 1915, vol. 10, pp. 172-179. Guild, F. N., "Microscopic Study of the Silver Ores", Econ. Geol., 1917, vol. 12, p. 306.

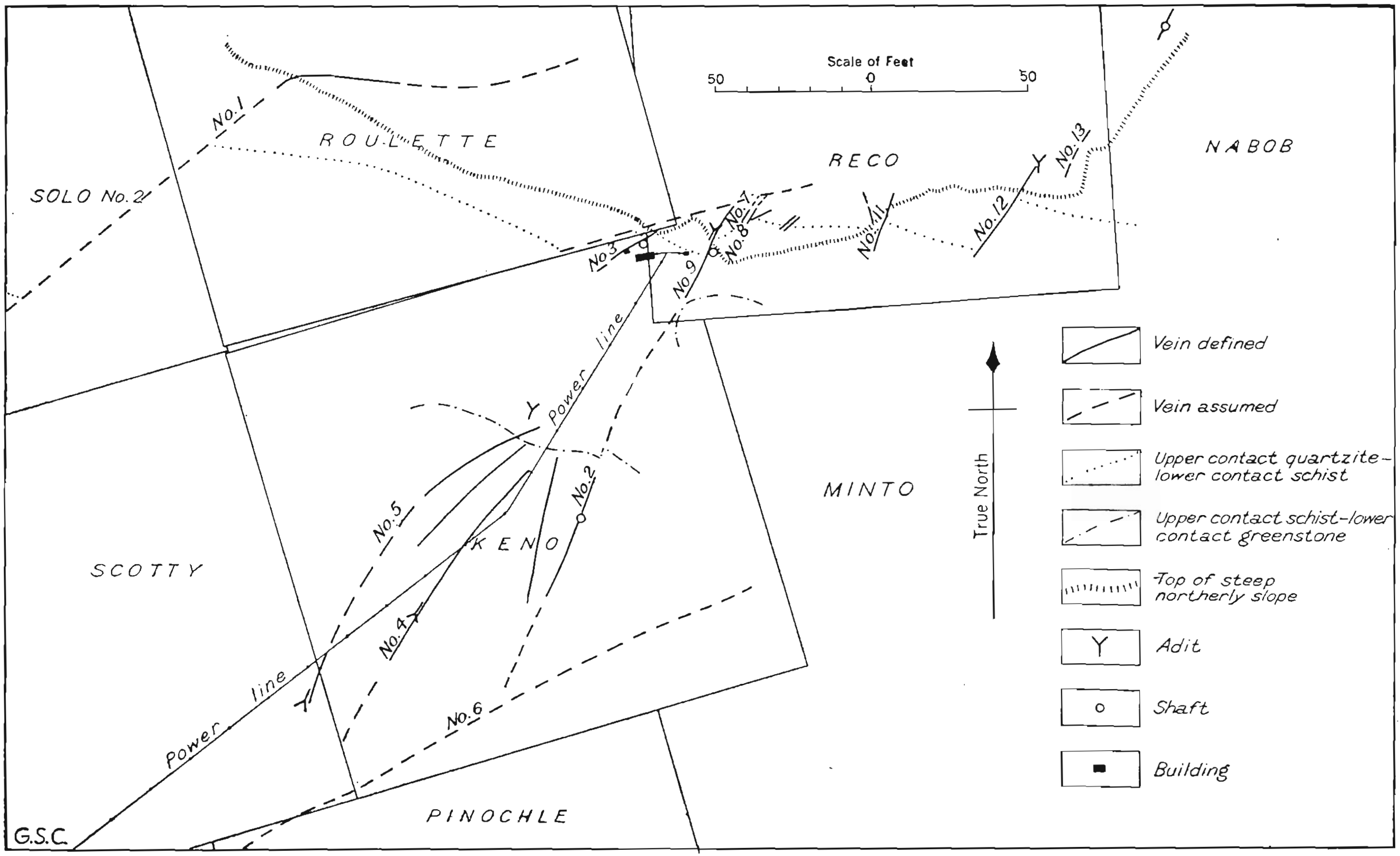

FIGURE 5. Plan of part of the original claims of Keno Hill, Limited, showing principal veins.

shipping grade has been discovered below the second level, although the workings have been carried to a depth of 400 feet. In the upper workings there were considerable masses of clean galena which could be shipped directly from the mine. In the lower workings the galena becomes disseminated and although high in grade will require milling before shipment. In the upper workings zinc averages 0·5 per cent, and in the lower workings from 7 per cent to 8 per cent. The possibility of other ore-shoots in this vein following the zone of schist on both walls of the fracture downward, has not been exhausted. The vein, if persistent, must also intersect a second longitudinal vein (No. 6) where chances for further ore-shoots would be increased.

Vein No. 1 has three adits, 230, 140, and 150 feet long. These are approximately 60 feet apart on the dip of the vein, and are connected by winzes. They tapped an ore-shoot 60 feet long and 14 inches thick in the upper workings, which, however, pinched out below. As this vein is one of the main fractures on the hill, having been traced across the original group and also found on the Maple Leaf claim of the Shamrock group, it is possible that other ore-shoots will be found along it. Vein No. 6, the second longitudinal vein crossing the property, is mineralized with quartz, arsenopyrite, pyrite, and jamesonite. The workings on it consist of several open-cuts. This vein carries small values in gold.

Vein No. 2 is probably the continuation of No. 9. A prospect shaft was sunk on it in 1920, but no further work was done. In veins Nos. 4, 5, and 12 small ore-shoots were encountered, but the largest ore-body in any of the veins, No. 9 excepted, proved to be less than 200 tons.

As a rule the veins on the original group had little gangue material. The ore where found was reasonably clean. More siderite was encountered in the veins in greenstone, i.e. Nos. 2, 4, 5, than in the others. Practically all the development done on the original group has been on fissures of the transverse type. These have proved to be disappointing. The ore-shoots have proved small, with the exception of No. 9 vein, and even this is small compared with deposits of a similar type in other districts.

Keno Hill, Limited, has suspended operations on the original group in order to prosecute the development of the Sadie-Treadwell vein, where the deposit gives greater assurance of permanency.

Sadie-Friendship Group

This group of claims was staked in 1920 and acquired by Yukon Gold Company in 1921. It consists of the Sadie and Friendship claims. Prospecting showed promise of a considerable body of ore, but little work was done until the winter of 1922-23 when a camp was erected, using a small boiler plant for power. Three prospect shafts, 35, 20, and 75 feet deep, were put down following the dip of the vein. From a short level close to the surface 360 tons of ore were extracted. The workings were allowed to fill with water, and work was suspended for the summer. With the closing of the workings on the original group electric power from the plant on Duncan creek became available. Buildings were erected, and a new shaft is now being sunk to a depth of 200 feet with crosscuts to the vein at 65, 130, and 200 feet.

The workings were flooded at the time of the writer's visit, so an examination of the property could not be completed. The vein as traced by shafts and open-cuts is apparently the same as that worked by Treadwell Yukon Company. From its course it is apparently faulted a number of times, but this could not be definitely established otherwise than by the offset of the vein, as the surface is everywhere covered with soil and vegetation, and the only outcrops are a few bodies of greenstone. It is considered likely that the faulting shown in the Treadwell Yukon Company's workings continues into this property. The extension of this vein to the south of the Sadie property has not yet been found. This is probably due to faulting, the vein being offset each time toward the west.

Lucky Queen

Amongst the claims being prospected by Keno Hill, Limited, is the Lucky Queen owned by H. Morrison. It is situated on Gambler gulch, on the northern slope of the hill. The workings consist of two short adits, and a winze 40 feet deep, but these were inaccessible in the summer of 1923 owing to caving. The information with regard to the property was furnished by A. K. Schellinger, engineer in charge of operations for Keno Hill, Limited.

The vein is about 2 feet wide and is composed largely of crushed country rock, cemented with quartz carrying freibergite. The freibergite occurs as stringers in the quartz, possibly 5 or 6 feet long and 1 or 2 inches in thickness. These stringers also penetrate the wall-rock. Near the winze is a cross-fissure carrying galena. During 1922-23, the company took out 20 tons of ore averaging about 200 ounces to the ton. Included in this shipment were seven sacks of selected ore averaging 700 ounces of silver to the ton.

The type of mineralization, i.e. quartz and freibergite, is unusual on Keno hill, and is exhibited only at a few points such as the Stone claim and the Lucky Queen. The reasons for the difference from the ordinary siderite-freibergite type are not apparent.

Treadwell Yukon Company, Limited

This company in 1921 acquired a number of claims on the western slope of the hill, adjoining the Sadie-Friendship group. The chief holdings include the Bluestone, Ladue, Lotus, Mary, Lansing, Bluebell, Poca Plata, Tunnel, Travice, and Silver Bell claims, and a number of fractions.

The workings are situated on the northern extension of the Sadie-Friendship vein, at an elevation of 4,500 feet. Three shafts have been sunk. No. 1 and No. 2, which attain depths of 280 and 175 feet respectively, are on the Ladue claim and about 400 feet apart. No. 3 is a prospect shaft on the Bluestone, which has been temporarily abandoned. Levels known as the 50, 100, and 200-foot have been driven connecting No. 1 and No. 2 shafts at depths of 50, 90, and 160 feet and the 300-foot level is being driven both north and south from No. 1 shaft. In addition, a drainage tunnel 3,000 feet in length is being driven to tap the vein at a depth of 500 feet. Comfortable buildings have been erected and the property is fully equipped with all the necessary mining machinery. Power is obtained chiefly by gasoline engines, but one Diesel engine has been installed and steam-power is also being used.

The ore is deposited along a shear zone, consisting of a fault which branches and reunites, with cross-faults at varying angles beween the main faults. This faulting shattered the country rock, and possibly also emphasized the jointing. The ore-bearing solutions filled the fissures and penetrated the country rock along all available openings, so that in places the country rock is cut by a reticulating series of veinlets of siderite. The growth of the ore-bodies along the openings is due in part to the replacement of country rock. The ore minerals are irregularly distributed. In many places they are sufficiently concentrated to permit of handsorting to a grade that can be shipped, in others concentration will be required. With the establishment of a concentrating mill on the property it is likely that the whole deposit will prove workable, and the cost of mining will be reduced by lessening the amount of development necessary at present to extract the shoots of clean ore.

Stopes have been started on the 50 and 100-foot levels. During the winter of 1922-23 the company shipped approximately 4,000 tons of ore, and a shipment of 6,000 to 7,000 tons is expected this winter.

Similar ore was found in the prospect shaft on the Bluestone claim, but this has not yet been developed. On the Lansing claim float from the same vein has been discovered. The total distance from the Sadie claim to the Ladue claim over which the vein has actually been traced is 2,200 feet; and it is extremely likely that prospecting will show it to continue farther north and south. The deepest workings at present are 280 feet, and the ore at that point is as high in grade as at the surface. As pointed out before, the evidence is in favour of primary deposition, and consequently much greater depths may be attained. Production from this source may be expected for some years to come.

Lake Group

The Lake group consists of three claims, Lake Nos. 1, 2, and 3, staked in an easterly direction from the northeast corner of the Lansing claim. These claims are owned by A. Hollenbeck, D. Cunningham, and R. Stewart.

Development work is practically all confined to the Lake No. 1 adjoining the Lansing claim, and consists of a shaft and a series of ditches used for ground-sluicing and a number of open-cuts. Float has been discovered at a number of points, but the main work has been confined to two veins occurring close to the southern boundary of the property.

The southern vein outcrops 100 feet from the boundary of the property, and strikes north 27 degrees east astronomic and dips 35 degrees to the southeast. It is 5 feet wide, and is mineralized with siderite, quartz, galena, chalcopyrite, freibergite, pyrite, and zinc blende. A shaft was sunk 15 feet, but sinking had to be suspended on account of the flow of surface water. Further work will be done this winter. To the west of the shaft the vein is cut by a southeasterly dipping normal fault of small displacement.

The second showing lies 150 feet to the north of the shaft and consists of a shear zone in schist, nearly parallel to the vein at the shaft. A short open-cut has been driven along the vein, which exhibits mineralization similar to that of the southern vein.

Galena float presumably from one of these veins was found in the open-cut near the eastern edge of the claim, but bedrock had not been reached. Further float has been discovered close to the centre line of the claim in the creek bed, and it is considered likely that an important vein crosses close to this point.

The veins exposed near the southern boundary of the property may possibly represent the northerly extension of the Sadie-Treadwell vein. This cannot be ascertained at present, as the surface of the intervening area is everywhere covered with drift, talus, and vegetation; moreover the area sustained considerable post-mineral faulting which in itself would render the course of the vein uncertain. The veins exposed are promising, and further work should be done both on these and on the opening of other veins indicated by float.

Onek Mining Company, Limited

The Onek Mining Company, Limited, was organized in 1922 to secure options on a number of claims in the Keno Hill area. This company was under the control of the Slate Creek Mining Company. A number of claims were prospected, but the chief work was done on a group, the Fisher, Lone Star, Galena Farm, and Rando, situated on the southern and western slope of the hill close to Keno Hill townsite. Operations were discontinued in 1922 and have not since been resumed.

A vein has been traced by means of a number of open-cuts across the Fisher, Lone Star, and part of the Galena Farm claims. On the Lone Star claim it is faulted about 100 feet to the north as shown by the line of open-cuts. The underground workings consist of a vertical shaft 135 feet deep and two levels at 50 and 100 feet, which are 30 and 97 feet long respectively. The vein gives evidence of continuity on the surface and there is no evidence of change in mineralization to the depth that workings have been carried. The mineralization consists of siderite, galena, and lead carbonate. A fairly persistent streak of galena varying from 2 to 20 inches in thickness is exposed in the workings. The values shown by a number of assays range around 80 ounces of silver to the ton. On the 50-foot level the galena averaged 80 ounces of silver; on the 100-foot level assays across a face of 12 inches yielded as high as 140 ounces. In the bottom of the shaft across a face of 8 inches the galena assayed as high as 165 ounces. On the 50-foot level the galena averages 20 inches in thickness; on the 100-foot level it varies from 3 inches up to 20 inches, and between the 100-foot level and the bottom of the shaft the vein flattens somewhat, and splits into two branches; the northern branch gave the assay referred to above, whereas the south branch has 4 to 5 inches of galena assaying 6 to 10 ounces. The values contained in the galena on this property are considerably lower than the average of the shipping ore from other properties which are shipping.

Onek Mining Company, Limited, also prospected a number of other claims, but the workings on these are not so extensive as on this group, and in many cases consisted only of representation work.

Gambler Group

The Gambler group is situated in the basin at the head of Faro gulch and consists of four claims, the Gambler, Lakeview, Madge, and Lost Chord, owned by A. Lamb, A. R. Thompson, C. Suttlemier, and A. H. Dever. The Gambler and Lakeview claims have been surveyed.

One of the main longitudinal veins of the area crosses this property. It has been found at intervals across the basin of Faro gulch, and probably extends much farther than it has been traced. Two adits have been driven on this vein on the Gambler claim. The upper is 50 feet above the lower and 81 feet south of it, and is 50 feet in length. An underhand stope 18 feet long and 12 feet deep is situated 18 feet from the entrance. The lower adit is 40 feet in length.

The vein, which varies in width from 4 to 6 feet, is mineralized with quartz, arsenopyrite, galena, zinc blende, freibergite, and siderite. The

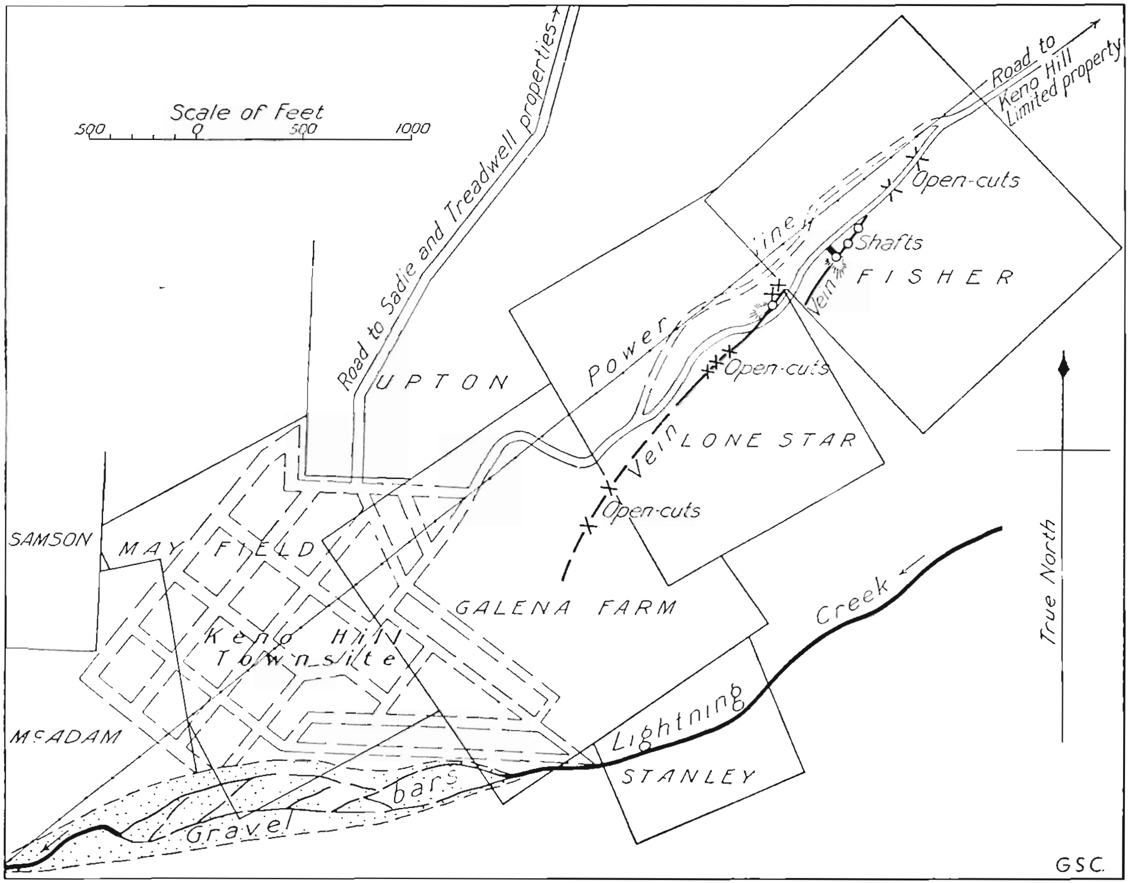

FIGURE 7. Claims of Onek Mining Company, Limited, and adjoining claims.

ore-shoot mined in the stope varied from 2 feet in width at the top to 3 feet 10 inches at the bottom. This stope yielded 53 tons of ore, about half of which assayed 230 ounces of silver and 34 per cent lead, and the remainder 135 ounces silver and 46 per cent lead. The ore in the stope is not yet exhausted. In the face of the lower adit, which lacks some 40 feet of being under the stope, is a seam of galena 16 inches thick.

Although the vein is one of the main fractures of the area it has been prospected only at one or two points. Other ore-shoots probably occur, and further prospecting should be done along this vein.

Silver Basin Claim

The Silver Basin claim is owned by R. Rasmusen and lies on the western slope of Silver Basin gulch. Development consists of one short adit and a number of open-cuts and trenches. Five veins, numbered in the order of their discovery, have been exposed in these workings. No. 1 vein is exposed in an adit which lies several hundred feet from the western boundary of the claim. It strikes north 67 degrees east astronomic and dips to the southeast at 60 degrees. The vein where exposed cuts quartzite, but a short distance above passes into schist. The mineralization is typical comprising galena, siderite, and freibergite. In running the adit a small shoot of ore was encountered which, however, was passed through. Further work on this vein is desirable, but this should not be carried into the overlying schist. No. 2 vein strikes north 74 degrees east astronomic and dips 37 degrees to the southeast. It is exposed in a small open-cut to the northeast of the adit, where it has a width of about 1 foot. The mineralization is mainly quartz and arsenopyrite, but a small amount of galena occurs. Vein No. 3 is exposed in several open-cuts at the top of the quartzite band referred to above, and a short distance below a sill of quartz porphyry. The strike and dip are variable, but the strike averages north 48 degrees west and the dip 75 degrees to the southwest. The mineralization is practically the same as vein No. 1. Vein No. 4 is one of the most important showings on the property. It is exposed in a series of open-cuts near the eastern boundary of the claim, and has a width of 4 feet. It strikes north 23 degrees west and dips to the southwest at 50 degrees. The mineralization shows quartz, galena, siderite, and freibergite. This vein has been traced over 100 feet by means of open-cuts, and also appears on the adjoining claim, Silver Basin No. 4, owned by M. Michie. The ore minerals are disseminated. Vein No. 5 lies 150 feet east of No. 3 above the quartz porphyry sill referred to. It is only partly exposed in an open-cut where it has a width of 8 feet and is mineralized with quartz, arsenopyrite, galena, freibergite, siderite, barite, and occasional flakes of native silver. It is cut off in the open-cut by a steeply dipping normal fault, the throw of which is small.

Four of the five veins discovered on this claim belong to the earlier or quartz-arsenopyrite type. There is ample evidence that transverse veins also occur, and it is likely that these are mineralized. These transverse faults are well shown in the upper bed of the quartzites which cross the property, and it is believed that further trenching will uncover veins other than those described.

Shamrock Group

The Shamrock group, consisting of seven claims and two fractions, owned by Messrs. A. Erickson, T. McKay, L. Beauvette, and A. Nickol, is situated near the summit of Keno hill, immediately to the west of the original holdings of Keno Hill, Limited. The workings consist of an adit 240 feet in length with three crosscuts, and three prospect shafts, from the bottom of one of which a drift was run. These workings are all on the Shamrock claim. On the Reno are two open-cuts, and one on the Maple Leaf.

The adit taps a vein 80 feet from the entrance, which is followed to the end of the workings. This vein varies from 6 inches to 3 feet in thickness. The mineralization consists of galena, with lead carbonate. Three tons of ore were stoped from above the drift and shipped.

The prospect shafts above the adit apparently encountered two parallel veins; the workings, however, had caved at the time of the writer's visit and very little could be seen. New shafts being sunk to the north encountered float from the same veins. From these workings a shipment of 60 tons was taken which assayed 170 ounces of silver and 7·48 per cent lead.

On the Maple Leaf claim an open-cut partly exposes a vein which is thought to be the continuation of Keno Hill, Limited, No. 1 vein. On the Reno claim two new veins were discovered during the past summer. These were only partly exposed, but showed heavy galena mineralization.

Butyer Group

The Butyer group consists of two claims, the Stone and Rye, owned by M. Butyer, who also owns a half interest in the intervening claim, the Scot. The principal workings lie on the Stone claim. The vein is exposed in three open-cuts on the northern slope of the hill, and an adit 245 feet in length taps the vein below. In the adit, the vein has a width of 12 feet and is mineralized with quartz, siderite, freibergite, chalcopyrite, and a little galena. The vein is considerably disturbed by post-mineral faulting. In the open-cuts above, the vein strikes north 57 degrees east and dips to the southeast. It has a width of 12 feet, and the filling is composed of schist fragments, with the interstices filled with siderite, galena, zinc blende, freibergite, and chalcopyrite.

S. Thurber and associates have a group of claims situated at the foot of the western slope of Keno hill, lying on the divide between Lightning and Christal creeks. This group consists of the following claims: Malcolm, Butte, Pippin Nos. 1 and 2, Mary, Ora, and Anaconda. The Solomon Fraction belonging to S. Thurber is not included in the group.

The workings consist of a shaft and crosscut on the Solomon Fraction, an adit on the Ora, and a number of open-cuts and trenches on the other claims. The shaft on the Solomon Fraction is 28 feet deep and vertical, and is followed by an incline of 15 feet and a crosscut of 15 feet. The deposit consists of a shear zone, the width of which has not been determined, which strikes approximately north 35 degrees east astronomic and dips 46 degrees east. The minerals present consist of quartz, arsenopyrite, pyrite, zinc blende, siderite, calcite, chalcopyrite, and galena. The ore minerals occur disseminated in a gangue of quartz, siderite, and calcite. The galena and chalcopyrite lie chiefly along the foot-wall of the deposit, and, passing over toward the hanging-wall, pyrite and zinc blende are apparently more common. At the time of the writer's visit the workings were largely filled with water and ice, so that only a very incomplete examination of the property could be made, and consequently no samples were taken. Values in gold are reported from this property. On the claims to the north of the Solomon Fraction are a number of open-cuts exposing shear zones which are, however, not so heavily mineralized as the zone at the shaft workings. The distance between these cuts is too great to prove that they are on the same vein zone as the shaft workings.

On the Ora No. 1, on the north side of Lightning creek, is an adit about 40 feet in length on a vein striking north 27 degrees east astronomic and dipping to the southeast at 45 degrees. The vein is mineralized with quartz, siderite, pyrite, zinc blende, but chiefly with pyrite disseminated in a gangue of quartz.

On the Butte claim there is a vein only partly exposed, with calcite, siderite, and a little galena.

Thunder Claim

The Thunder mineral claim is situated on Sourdough hill, which lies south of Keno hill across Lightning creek. It is owned by M. Mellish and is under lease to J. Gillis, J. McHugh, and J. Curley.

The workings, in addition to several open-cuts, consist of a shaft and incline 8 feet deep and a drift south from the shaft of 65 feet. There is also a crosscut 6 feet long about 15 feet south of the shaft. The vein was originally discovered in two open-cuts; in the upper cut galena and siderite were found, and in the lower cut, siderite. The shaft lies about midway between the two cuts, and the underground workings are being driven towards the upper cut.

The vein as exposed in the underground workings varies considerably in strike, dip, and thickness. The average strike is about north 30 degrees east astronomic and the dip from 70 degrees to the southeast to vertical. The vein has a thickness of from a few inches to 7 feet. The greater part of the vein filling is siderite. The chief ore minerals are freibergite and galena. These both occur in small bunches, the former apparently favouring the hanging-wall, whereas the latter occurs at random in the vein and also impregnating the wall-rock. Associated with the freibergite are the oxidation products, malachite and azurite. Pyrite, arsenopyrite, and chalcopyrite also occur in small amounts, the pyrite occasionally enclosing the galena. Where the freibergite is present high values in silver are obtained.

Conclusions

In spite of the fact that the clean shipping ore from the veins on the original holdings of Keno Hill, Limited, is exhausted, the camp is in a much better position at present with regard to probable tonnage than in 1920, owing to the discovery of new veins, particularly on the western and northern slopes of Keno hill. The most important of these discoveries is the Sadie-Treadwell vein, which has a known extent of 2,200 feet and a much greater probable length. Workings have been carried to a depth of 300 feet without diminution in values. The ores are primary and should extend to greater depth; and, though it is conceded that changes in the primary mineralization may take place with depth, no sudden drop in values is looked for. Workings to tap this vein at a depth of 500 feet are already in progress.

Although considerable prospecting has been done, by far the greater number of claims may be classed as unprospected. This is due chiefly to two causes. In the first place the frozen ground renders trenching exceedingly difficult and costly, and surface water interferes with sinking. In the second place supplies are costly, rendering it difficult for the prospector without financial aid to maintain himself on his claim for extended periods. A large amount of work has been done by the use of water for ground-sluicing, and several important veins have been discovered. Over much of the hill, however, water is available for this purpose only for very short periods. Discoveries have been made on Bunker and Sourdough hills to the south and Galena hill to the west, and in some instances the typical Keno Hill mineralization is developed. Further discoveries on these hills are expected*.

*The succeeding pages (22-28) of this Summary Report comprise the report by W. E. Cockfield on the "Silver-Lead Deposits of Beaver River Area". They are not reprinted here as Dr. Cockfield returned to this area in the following year and later submitted a complete report on both seasons' work. This was published in the Summary Report for 1924, part A, and is reprinted in this volume. (H. S. B., 1956.)

1924

Introductory Note

The following paragraph, by G. A. Young, Chief Geologist, is included in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1925, page 14:

"W. E. Cockfield made a detailed examination of the silver-lead deposits of the Upper Beaver River area, Mayo district, and geographically and geologically surveyed an area in the general vicinity of the deposits. A full account of this work, accompanied by a map, appears in the Summary Report, 1924, part A. Cockfield also completed the mapping of a quadrangle between latitudes 60 and 61 degrees and longitudes 134 and 136 degrees in the vicinity of Whitehorse. This work was commenced in 1922; its completion permits the preparation for publication of a map and report dealing with an area of 4,500 square miles within which occur various types of mineral deposits."

At the end of the Summary Report for 1924, part A, page 149, the Director includes the following note under the heading "Other Field Work":

"*W. E. Cockfield.* Cockfield completed the geographical and geological mapping of an area of 4,500 square miles in southern Yukon, between latitudes 60 degrees and 61 degrees and longitudes 134 degrees and 136 degrees, which was begun in 1922. This area includes a section of the eastern margin of the Coast Range granite batholith, in which Conrad, Whitehorse, and Wheaton mineral areas occur and which is geologically favourable for the existence of other metalliferous deposits. The results of the investigation are now being prepared in the form of a memoir and a geological map on a scale of 1 inch to 4 miles, for encouragement and direction of prospecting in the area."

UPPER BEAVER RIVER AREA, MAYO DISTRICT

by W. E. Cockfield

Silver-lead deposits were discovered in 1922 on McKay hill, in the vicinity of Upper Beaver river, and as the discovery followed so closely that of Keno hill, a stampede to the area occurred, and numerous claims were staked. Subsequent prospecting, however, showed that the deposits were low grade, and many of the claims were abandoned. In 1923, prospecting of the area continued and resulted in the discovery of the deposits on Silver hill, and also of high-grade float on Grey Copper hill. These discoveries did not become known until midwinter when a second stampede to the area took place and some fifty claims were staked around the discovery claims of Grey Copper hill. As the staking took place in the winter it was not until the spring of 1924 that any development could be undertaken, and on account of the retarded summer very little effective work could be done on most of the claims until June or July. Many of the claims, therefore, had no showings of mineral in place on them.

In 1923 the writer made a hurried trip to McKay hill, and a report on the properties there was published*. In 1924 about two months were spent in the area. The work included the mapping, on a scale of 2 miles to the

*Cockfield, W. E., Geol. Surv., Canada, Sum. Rept., 1923, pt. A, pp. 22-30.

inch, of an area including all the known deposits, and the preparation of more detailed plans of some of the deposits. The writer was assisted in this work by Messrs. C. H. Stockwell, B. B. Brock, and S. Gibson, all of whom performed their duties in a highly satisfactory manner. Thanks are also due to the prospectors met in the district, who assisted in many ways in forwarding the work.

Location and Means of Access

Upper Beaver river area as mapped comprises that part of the watershed of Beaver river lying to the west of Braine creek. The area is best reached by means of the stampeders' trail from Keno hill to McKay hill. This trail, although designed as a winter route and swampy in part, nevertheless affords a fair summer route to the area, and offers no insuperable difficulties to the use of pack animals. It follows the valley of the south fork of McQuesten river to McQuesten lake, and thence crosses the hills to the valley of the north fork of McQuesten river, which is followed nearly to its head, where a low pass leads to Beaver river valley. From this point two routes are available to the different properties; the trail which follows up Falls creek, passing McKay hill, and crossing a high summit to Police creek where it terminates, is most used in summer. From Police creek to the various properties on Carpenter creek, trails are scarcely necessary as the country is open and the gravel bars of the creeks afford good travelling. The northern descent of the pass from McKay hill is somewhat steep and during the early part of the summer is blocked by deep snow-drifts. The second route follows Beaver valley to the mouth of Carpenter creek and thence up Carpenter creek to the various properties. This is a good route in winter, but in summer that part of Beaver valley which it traverses is swampy. The distances of McKay hill, Grey Copper hill, and Silver hill from Mayo, following the Keno hill road and the stampeders' trail, are approximately 87, 99, and 107 miles, respectively.

It may also be pointed out that a canoe route to the area is available. In 1905 Camsell and Keele, of the Geological Survey, ascended Stewart and Beaver rivers as far as the mouth of Braine creek, and it seems probable that gasoline launches might ascend Stewart and Beaver rivers from Frazer falls to the mouth of Rackla river. This, however, would require portaging around Frazer falls some 50 miles above Mayo in order to establish communication with lower Stewart river.

Topography

Upper Beaver river area lies within the Ogilvie range, a spur of the Mackenzie mountain system. The Ogilvie range at this point forms the height of land between Yukon and Mackenzie rivers basins, and separates the waters of the Stewart on the one hand from those of the Peel on the other. The range is rather rugged; the higher peaks attain elevations of 6,500 to 6,700 feet above sea-level. Few peaks exceed this elevation. The floors of the larger valleys stand at elevations of from 2,500 to 3,000 feet. The maximum vertical relief is, therefore, around 4,000 feet.

The hills are long, branching ridges with knife-edged crests, surmounted by small, ragged peaks mostly composed of the more resistant rocks. Towards the height of land the presence of a somewhat flat-lying limestone has a marked effect upon the topography, as, owing to differential erosion, it weathers into castellated forms with numerous cliff faces, giving to the hills an extremely rugged appearance.

The main valleys are longitudinal, following in a general way the trend of the strata. Only one of these valleys occurs in the area mapped, namely Beaver river valley; but Camsell* notes the parallelism of the valley of Nash creek and upper Wind river with that of Beaver river. The valley of Beaver river upstream from the mouth of Braine creek has a general northwest trend, with a width of 2 to 3 miles. The main branch of Beaver river enters this valley from the southwest at the mouth of Carpenter creek; the main valley, however, continues to the northwest and is occupied in turn by parts of Carpenter, Police, and McLean creeks, and, across the divide, by a stream tributary either to Wind river or Hart river. The divide between Police creek and this stream is formed by a low, gravel ridge.

Beaver valley is joined by shorter and narrower transverse valleys. The two principal valleys of this type are those of Braine and Carpenter creeks; that of Braine creek has been described by Camsell** in detail, and the valley of Carpenter creek so closely corresponds to the description that it need not be described at length. In general, it may be said that these valleys have each several parts with steep grades, or even canyons, between which the stream bed spreads out over the entire valley floor in a network of ever-changing channels, forming typical braided watercourses. These broad gravel flats, having a width of half a mile or more, in the spring are occupied by large sheets of ice 8 to 10 feet thick, caused by the overflowing of the water in cold weather. In the upper parts of the valleys it is doubtful whether these ice-sheets entirely disappear during the summer, as in August one several acres in extent and having a thickness of from 6 to 20 inches was noted on Carpenter creek.

The larger valleys afford good proof that they were glaciated during the Pleistocene period. On the upper part of Carpenter creek, the level of the ice did not extend much above the present-day timber-line, that is about 4,500 feet above sea-level. Below that level the valley exhibits the scouring typical of a glaciated valley, with numerous glacial forms and striæ. Above it the hills rise in bold, rocky faces totally devoid of any signs of glaciation. In the lower reaches of the valleys the elevation attained by the ice was somewhat lower. The direction of ice movement, where determined, was apparently outward from the crest of the range.

Geology

The rocks exposed in this part of the Ogilvie range comprise both sedimentary and igneous types; the former, however, predominate and underlie by far the greater part of the area. The sediments have been divided into three main groups and the igneous rocks into two groups. The following table gives the general subdivisions of the rocks, and the age relations will be discussed in connexion with each group.

*Camsell, C., Geol. Surv., Canada, Ann. Rept., vol. XVI, p. 17CC.
**Camsell, C., idem., pp. 11CC-14CC.

Era	—	Lithology
Quaternary................	Superficial deposits.........	Chiefly valley accumulations; gravel, sand, muck, and glacial deposits
		Augite diorite
		Augite andesite with tuffs and breccias
Palæozoic.................	Devonian to Ordovician.....	Limestone and shaly limestone
		Volcanic agglomerate, shale, and sandstone
Precambrian (?)...........	Tindir group (?)...........	Calcareous sandstone, slate, argillite, and limestone
		Quartzite, slate, limestone, and conglomerate

Precambrian (?)

The Precambrian (?) group, consisting of quartzite, slate, limestone, and conglomerate, occurs only to the south of the main depression forming the valleys of Beaver river and Police creek. On account of the fact that wherever found the rock assemblage was separated by this wide valley from the other rocks of the district, its age relations were not obtained. From a study of the lithology it seems probable that this group, together with the second Precambrian* group formed of calcareous sandstone, slate argillite, and limestone, represents the Tindir group described by Cairnes* from the International Boundary section. On the boundary the age of the Tindir group was determined as pre-Middle Cambrian, with a strong probability that the rocks are Precambrian. In Beaver river area, the second of the two groups mentioned is known to be pre-Ordovician. The lithological characters of the rocks in Beaver River area and on the boundary 200 miles away are in many respects identical, but as similar rocks have been described only from one intervening point** and where also their age was not determined, any correlation must remain entirely tentative until further work be done.

The quartzites are white, light grey, or blue, and at a distance may easily be mistaken for limestone. They are metamorphosed to a certain extent, but have not suffered nearly so much in this respect as the quartzites of the Yukon group. Under the microscope they are seen to consist of interlocking grains of quartz and feldspar with a small amount of sericite and, in some specimens, calcite or dolomite. Occasional beds contain a certain amount of mica and chlorite arranged in streaks between layers of purer quartzite. The quartzites occur mainly to the south of Beaver river,

*Cairnes, D. D., "The Yukon-Alaska International Boundary", Geol. Surv., Canada, Mem. 67, 1914, pp. 44-57.
**Cockfield, W. E., Geol. Surv., Canada, Sum. Rept., 1918, pt. B, p. 16.

and interbedded with them are beds and bands of white crystalline limestone, and red and green slates. The latter occur as narrow beds between more massive beds of quartzites. The limestone on the other hand in many places attains thicknesses of 50 feet or more, but the beds apparently die out along their strike to be replaced by others at different horizons.

Between Beaver river (west of the mouth of Carpenter creek) and Police creek, slates predominate. These are red, green, grey, or black and included in them are thin beds of quartzite and conglomerate, and more massive beds of white or grey crystalline limestone.

The quartzite-slate group is closely folded and in many places faulted. Between Police creek and Beaver river the dip is prevailingly to the north, but changes rapidly from place to place indicating an extremely complex structure. To the south of the Beaver the dips are prevailingly to the south and mostly at from 50 to 85 degrees.

The pre-Ordovician sediments to the north of the main depression forming the valleys of Beaver river and Police creek, are calcareous or dolomitic sandstones and limestone, with slates and argillites. These rocks weather a dull red to brown and viewed from a distance give the hills a bright red appearance perceptible at distances of 50 miles or more. As these form the country rock of some of the ore deposits this feature is of some importance, for the areas where such rocks occur may be discerned from a distance.

The calcareous or dolomitic sandstones are composed of varying proportions of calcite or dolomite, and quartz. Viewed under the microscope the rocks are seen to be extremely fine in grain, with calcite or dolomite, and quartz, arranged in layers, giving to the rock a laminated appearance; this lamination is accentuated in weathering by the solution of the more readily soluble material. Associated with these are smaller amounts of sandy, white limestone. The slates are red to brown, and break readily into plates 1 to 2 feet in diameter. Associated with the slates are dark-coloured or black argillites. These rocks are everywhere closely folded and, in many places, faulted.

Volcanic Agglomerate, Shale, and Sandstone

The principal exposures of these rocks are found near the base of the Ordovician-Devonian limestone. Outcrops at other localities, however, suggest that they may occur also at higher horizons. The thickness varies rapidly from place to place. On the upper part of Carpenter creek these rocks are exposed on the eastern side of the creek, on a steep hillside, where they attain a thickness of considerably over 1,000 feet. To the west of Carpenter creek they thin rapidly and finally disappear. They are again developed, but apparently at a higher horizon, to the north of Castle mountain; along the hills facing Beaver valley these rocks appear in a narrow, yet continuous, band close to the base of the limestone.

The major part of the material is volcanic in origin, and is probably related to the augite andesites, but differs from the agglomerates directly associated with the andesites in that rounded pebbles and boulders of rocks other than greenstone are also present. Lithologically the bulk of the rock is composed of augite-mica andesite, and is dark green to dark purple. Microscopically the rocks consist mostly of secondary minerals chiefly chlorite and calcite. Occasional crystals of biotite and augite occur, and in some specimens patches of brown volcanic glass. The feldspars are turbid and altered. The groundmass is largely altered to calcite, but where preserved is microcrystalline. Pebbles and boulders of the Tindir and other rocks, quartzite, slate, limestone, calcareous sandstone, and greenstone were observed. The number of pebbles varies greatly from place to place. In certain parts, however, they are fairly abundant. Associated with the agglomerate are beds of dark-coloured shales and sandstones.

Ordovician-Devonian Limestone

This limestone is almost invariably white or slate-coloured, and as a whole is somewhat massive-bedded over the greater part of the area, though shaly and sandy members are present.

The limestone occurs in two areas or bands; one of these outcrops along the hills bordering Beaver valley on the north, and the other occupies the larger part of the northern part of the area. These two bands are thought to represent the limbs of an anticline, the central part of which has been removed by erosion. The southern band has a dip of 25 to 50 degrees to the south and the northern band a gentle dip to the north. To the north and west, beyond the area surveyed, the limestone apparently flattens, and, farther away, assumes a southern dip, forming a broad, shallow syncline.

Fossils are present, but are by no means abundant. Corals are extremely plentiful at various localities, and form coral reefs, but large areas of the limestone appeared unfossiliferous. The following fossils were collected during the summer and determined by E. M. Kindle of the Geological Survey.

Lot No. 7662: Horizon, Devonian
Favosites cf. *digitatus*
Favosites cf. *radiatus*
Cyrtina cf. *umbonata*

Lot No. 7956: Horizon, Silurian
Favosites cf. *favosus*
Stromatopora cf. *antiquua*

Lot No. 7960: Horizon, Silurian
Bryozoa (undeterminable)
Megalomus cf. *canadensis*

Lot No. 7961: Horizon, Silurian
Cladopora cf. *cervicornis*
Orthis flabellites
Whitfieldella nitida

Lot No. 7964*: Horizon, Silurian or Ordovician
Actinoceras sp. allied to *A. richardsoni*

Lot No. 7963: Horizon, Silurian or Ordovician
Strombodes sp.
Zaphrentis vel *Streptelasma* sp.
Eridophyllum sp.

Lot No. 7958: Horizon, Silurian and Ordovician
Favosites cf. *favosus*
Columnaria alveolata
Bryozoa ? not determinable
Cornulites n. sp.
Lophospira sp.

*Donated by J. McLean, Keno hill, Yukon.

Lot No. 7959: Horizon, Ordovician
Columnaria alveolata
Zaphrentis ? sp.
Eridophyllum cf. *rugosum*
Halysites n. sp.

Lot No. 7957, consisting of graptolites, was determined by Dr. Ruedemann who reports as follows: "The faunule from the Beaver River district of Yukon Territory is not very good material, but I could make out the following forms, apparently all that there are.

Didymograptus sp. two forms, fragments
Dicranograptus sp. nov. cf. *ramosus* Hall
Climacograptus cf. *antiquus* group
Glyptograptus cf. *teretiusculus euglyphus* (Lapworth)

This faunule would indicate a late Normanskill age for the beds. In *Climacograptus antiquus*, *Glyptograptus euglyphus*, and the coarser of the *Didymograpti*, it suggests the fauna described by Lapworth from Dease river, and Kicking Horse pass, British Columbia, but the faunule is too small for definite correlation."

Mr. Kindle in reporting on the collection says: "The Halysites in lot 7959 represents a type which we generally consider to be confined to Ordovician faunas, and which appears to be identical with a new Richmond species or variety in the Lake Windermere district of British Columbia. Lot 7958 appears to include both Ordovician and Silurian species.

The Ordovician fauna collected by D. D. Cairnes from the Alaska Boundary section* (XI K 46) appears to be the same as that represented by faunule 7960 in the above list. The Silurian elements in the collection show Niagaran affinities. The Devonian collection is too small both in individuals and species to offer more than the observation that it probably represents a Middle Devonian horizon."

Lots No. 7956 and 7963 were obtained from the southern limestone area, and the balance of the fossils from the northern area. The Devonian fossils were obtained from one locality only, namely at the head of Carpenter creek, close to the height of land. It seems probable that within the area mapped the Devonian is represented only to a slight extent and that practically all the limestone mapped belongs to the Ordovician or Silurian. No definite break was recognized between these two systems.

The limestone overlies unconformably the calcareous or dolomitic sandstones, slates, and argillites classed as pre-Ordovician. The relations were best determined in the vicinity of Silver hill where the pre-Ordovician rocks dip at 50 to 85 degrees to the west and the limestone 15 degrees to the west. The unconformity is indicated in a similar way on Grey Copper hill and at other points in the area.

As the Ordovician-Devonian does not occur with the Tindir rocks found to the south of Beaver valley, it must be assumed that this area was a landmass during these periods, or that the limestone, if deposited, has since been removed by erosion. In the latter case one would expect to find patches of limestone on the higher summits, as in the area of Tindir rocks immediately to the north of Beaver valley, but no such outcrops of limestone were observed. It, therefore, seems reasonable to assume that this area was a landmass in Ordovician to Devonian times.

*Geol. Surv., Canada, Mem. 67, p. 67.

Augite Andesites

Rocks of this type are abundantly developed in the area. They are most numerous in the hills between Beaver river and Police creek, but also occur in both the pre-Ordovician rocks and the limestone north of Beaver river valley. In the quartzites to the south of Beaver river they are scarce. Both intrusive and extrusive types are present. Due to better outcrops they are best seen in the limestone areas where they occur chiefly as sills, in some cases persistent over considerable distances. None was noted in the higher parts of the limestone series.

In the area to the south of Beaver valley both intrusive and extrusive types occur. Both are later than the pre-Ordovician sediments, and lacking definite evidence to the contrary are assigned to the same period as the intrusives cutting the limestone farther north.

They are dark green, fine-textured to aphanitic rocks which under the microscope show advanced alteration to secondary minerals. The main constituents are augite and feldspar in a groundmass that is in many places almost completely altered to chlorite and calcite. Associated with them are tuffs and breccias, the latter being composed of angular fragments of the intruded rock and angular and rounded fragments of greenstone. Many of the breccias on examination show angular fragments of greenstone cemented by calcite. Vugs and amygdules occurring in the rock are filled with calcite, which has also replaced neighbouring parts of the rock to form large masses of this mineral. The breccias or agglomerates differ from those previously described in that in addition to greenstone they carry fragments only of the rock intruded, whereas the previously described agglomerates contained rounded fragments of other sedimentary rocks.

No definite data as to the age of the greenstones of Beaver river are available, other than that they are later than the rocks they cut or overlie. In the lack of definite evidence to the contrary, however, the augite andesites may all be considered to belong to one period of igneous activity not older than the Silurian and perhaps Devonian, though the greenstones were not noted cutting the uppermost limestones.

Augite Diorite

The intrusions of augite diorite are of small areal extent. One sill-like mass was noted to the west of Carpenter creek and several sills south of Beaver river. They vary considerably in grain, from coarse to fine, but are holocrystalline and characteristically of a granitic habit. The principal minerals are pyroxene (augite) and plagioclase feldspar (andesine). These are accompanied by secondary minerals, chiefly chlorite and calcite.

The age relations of the augite diorites to the limestone were not definitely determined. At the only point where they were observed in juxtaposition the contact was obscured by talus. The data on the age relations of the diorites and andesites are inconclusive, but it is thought that they belong to the same general period of vulcanism and that cooling under different conditions gave rise to different types.

Superficial Deposits

The areas of superficial deposits outlined on the map are the occurrences in the larger valleys where their thickness is probably so great as to preclude the possibility of prospecting bedrock. The areas thus indicate the positions of the major valleys. The superficial deposits represent accumulations of an unknown thickness of gravel, sand, soil, muck, and glacial deposits of Pleistocene and Recent age.

Economic Geology

The staking of McKay hill in 1922 led to further prospecting in the district, with the result that deposits were discovered on the south end of Carpenter hill the same summer, followed by the finding of ores on Silver hill and Grey Copper hill in 1923. The only known deposits of mineral in upper Beaver river area occur on these hills and consist of silver-lead and silver-copper ores. Of these, the former are the more plentiful.

The silver-lead ores consist of galena with subordinate tetrahedrite and zinc blende in a gangue of quartz or calcite. A number of samples taken of the veins indicate a relatively low content of silver, and this is confirmed by a larger number of samples of vein float taken the previous summer (1923). Where tetrahedrite is present the silver content increases, but samples of fairly pure tetrahedrite show in most cases less than 70 ounces of silver to the ton. In one case, namely Grey Copper hill, tetrahedrite float assaying 900 ounces of silver to the ton has been reported, but none of this was available on the ground at the time of the writer's visit.

Description of Properties

Silver Hill

Silver hill is situated near the head of Ervin creek, a tributary of Carpenter creek. It is a knife-edged ridge forming a northern spur of Carpenter ridge. Eight claims and two fractions, staked two deep across the ridge have been located by J. Carpenter, E. Ervin, and J. McLean, of Keno hill. Several claims have been staked at either end of the group by other parties.

The rocks outcropping along the ridge consist of calcareous or dolomitic sandstones, intercalated with which are beds and thin layers of impure sandy limestone. The strata strike in a general way along the ridge and dip at angles of 50 to 85 degrees to the west. Both strike and dip, however, vary rapidly from place to place. The western slope of the ridge forming the dip slope is steep, and exhibits numerous outcrops, particularly above the talus slope at the base. It is on this steep hillside that all the deposits located to date have been found. The eastern slope of the ridge is gentler and is covered with a thick layer of soil, moss, and vegetation. Intrusive in the sandstone are several bodies of greenstone. The largest of these outcrops on the ridge to the east of Silver hill, in such a position that the beds of sandstone carrying the ore deposits lie above its upper contact. On the ridge to the west of Silver hill the Ordovician-Devonian limestone overlies unconformably the calcareous sandstones.

The calcareous sandstones of Silver hill have been faulted to some extent. Many of the faults are transverse to the strike of the strata, but several strike faults were noted. The fissures as a rule are short. There is no direct evidence as to the age of these fissures; they have not been traced from one formation to another. It may be stated, however, that the Ordovician-Devonian limestone has also been faulted in many places, though this faulting may have taken place at an entirely different period. It is possible that the short, transverse faults are due to minor crustal adjustment accompanying the intrusion of the greenstone masses.

The ore deposits have formed along the short, transverse fissures which served as channels for the mineralizing solutions. Mineralization apparently took place by replacement of the wall-rock along these fissures; the replacement was apparently of a selective character, the impure limestone beds offering the most favourable spots for the formation of ore-bodies. The minerals are not confined to the fissures, but in many cases extend out to varying distances as disseminated ore. The mineralization consists of galena with subordinate zinc blende and a little pyrite in a gangue of calcite and siderite. Quartz is present only in minor amounts. The galena observed at the surface is quite fresh, being coated only with a thin film of carbonate, but in some places an iron capping composed chiefly of limonite occurs to a depth of a few feet. The position of the ore-bodies near to the underlying greenstone, and the lack of other igneous rocks in the neighbourhood, suggest that the mineralizing solutions may have had their origin in the magma which formed this greenstone mass.

The workings consist of a number of prospect pits or trenches. On the accompanying plan numbers have been placed at different localities for purposes of reference, and these locality numbers are employed in the following descriptions.

At locality No. 1 a vein or lens of ore has been traced for 50 feet on the hillside by means of three trenches. In the lower trenches the ore-body is 2 feet thick and in the upper or eastern trench 6 feet. Probably it will extend considerably farther in both directions. As exposed it consists almost entirely of massive galena, fairly free from gangue, with pyrite, zinc blende, calcite, and siderite. Another vein lying 50 feet to the north and roughly parallel occurs at locality No. 2. It has been traced by trenches for 175 feet, has a thickness of 4 to 6 feet, and where exposed is bounded by definite unmineralized walls of contorted calcareous sandstone. The mineralization is identical with the body at locality No. 1, save that no siderite was noted. A sample was cut across the maximum exposed width of 6 feet, and the assay returns showed 9·00 ounces of silver to the ton and 69·38 per cent lead.

At locality No. 3 a vein has been partly exposed in an open-cut. The vein consists of disseminated galena and has a width of 4 feet. This vein may possibly represent a continuation, along the strike, of the deposit at locality No. 4, where an outcrop of country rock carries irregular bodies of massive galena over a total width of 100 feet. The distribution of the sulphide is highly irregular, although very few pieces of the rock can be obtained which do not show specks of galena or pyrite. The largest mass of galena noted was exposed for 30 feet and had a thickness of 6 inches to 1 foot. At locality No. 5, a little to the north of this zone, a vein of 3 feet carrying some disseminated galena is partly exposed in a trench. This may represent an extension of the larger deposit described above.

At locality No. 6 is one of the largest of the deposits on the property. It is not well exposed, but appears to be a tabular body 26 feet thick where it is crossed by a trench, and strikes north 30 degrees east with a dip of 68 degrees to the northwest. This ore-body is exposed only in the single cross-trench and consequently its length is unknown. It is composed mostly of galena, but carries a little pyrite and zinc blende. Near the hanging-wall there is a horse of unreplaced country rock. The walls at either side of the deposit are not well exposed. The foot-wall where seen is sharply defined, but on the hanging-wall side the country rock shows disseminated galena a short distance from the deposit. A sample was cut along the face of the trench, excluding, however, material from the horse of country rock and the assay results showed 4·5 ounces of silver per ton and 65·46 per cent lead. Forty feet to the north is another showing (locality No. 7) with 5 to 6 feet of galena disseminated through country rock. It has not been prospected.

Locality No. 8 is on the Irene claim 1,100 feet northeast of locality No. 7. Here two or more faults of different strike intersect limestone and form a fault breccia a few yards in diameter which has been partly cemented with galena and pyrite. The sulphides also occur in the country rock for distances of at least 100 feet from the fault breccia, but nowhere is any large body of ore visible.

Locality No. 9 shows a small seam of massive galena exposed for a few feet along its strike. At localities Nos. 10 and 11 galena float is present and apparently indicates the existence of one or more concealed deposits, for it occurs in such a position that it could not have come from any of the known deposits.

At localities Nos. 12 and 13 at the northern end of the hill several showings of massive galena in place are partly exposed. Work on these showings had not been commenced at the time of the writer's visit, but they may represent parts of the same lode. A large quantity of float in the slide rock below suggests the occurrence of an ore-body of considerable size.

Grey Copper Hill

Grey Copper hill is situated 4 miles north of the mouth of Carpenter creek. The discovery, by R. Fisher, in the autumn of 1923, of rich tetrahedrite float on this ridge, led to a stampede to the district during the winter of 1923-24. About fifty claims were staked, most of them being located on the snow. Only the assessment work required to hold them was done during the summer of 1924.

Only one mineral vein was noted, but float from one or more other veins was observed. The available evidence indicates that the deposits are tetrahedrite-pyrite-siderite veins somewhat similar in type to those occurring on Keno hill, except that galena is an important constituent of the veins on Keno hill, whereas no galena was noted on Grey Copper hill.

The only visible vein noted occurs on the discovery claim—the Grey Copper King. This vein outcrops in a small canyon in a gulch on the western face of the hill, a few hundred feet above timber-line. It is partly exposed in a small open-cut on the northern side of the canyon. Along the strike of the veins, rock exposures are wanting on the opposite side of the gulch and no attempt has been made to discover if the vein continues in this direction. The vein occupies a fault fissure striking north 10 degrees west and dipping 78 degrees to the southwest. It is not exposed for its full width, which is estimated to be 24 to 30 inches. The vein-filling consists of siderite, tetrahedrite, and pyrite with some quartz, azurite, and malachite. The siderite makes up by far the greater part of the deposits and is coarsely crystalline and of a light brown colour. Tetrahedrite and pyrite are scattered through the siderite in small specks and bunches. A sample of the 16 inches of the vein exposed was taken, and assayed 52·0 ounces of silver to the ton.

The second discovery on Grey Copper hill consists of float only and was also made by R. Fisher. It lies on the King Tut claim, toward the head of the gulch already referred to. On this claim, owned by R. Fisher, and the adjoining Silver Queen, owned by L. B. Erickson, siderite float has been found. Occasional lumps of fairly pure tetrahedrite carrying up to 1,100 ounces of silver to the ton have been picked from this float, but none was observed by the writer although a careful search was made. The bedrock of the gulch at this point is wholly covered by a thick accumulation of frozen talus, and this, in addition to a large snow-drift which remained most of the summer, prevented the prospectors from sinking their trenches to bedrock during the past season. A body of siderite about 20 feet long and of unknown thickness was noted in place on the southern side of the gulch. There can be little doubt that a concealed siderite-pyrite-tetrahedrite vein crosses these properties, and that the tetrahedrite carries high values in silver, but the position and course of the vein, its width, and the character and value of its ore-shoots, must remain unknown until further prospecting has been done.

On some of the other claims, quartz and siderite float have been discovered, but to date the veins from which this came have not been located.

McKay Hill and Neighbouring Hills

McKay hill is situated between Beaver river and Police creek. The chief claims with mineral showings are: the Carrie and Whiterock, owned by L. B. Erickson; the Snowdrift, owned by W. F. McKay; and the Black Hawk, owned by C. Beck.

The mineral deposits occur in and at the borders of small masses of largely amygdaloidal andesites and andesitic breccias in which calcite fills the amygdules and replaces the original constituents of the rocks. No deposits are known in the Tindir slates which occur at this point. The deposits are exposed only in a few instances; in most cases their presence is indicated only by float.

The positions of the exposed bodies and the distribution of the float indicate that one mineralized zone crosses the southern face of McKay hill with a general strike of north 30 degrees east magnetic, and that it passes close to the common corner of the four claims. It cannot be stated definitely whether this zone is a continuous vein with ore-shoots at intervals, or whether it consists merely of a number of distinct lenses of mineral arranged along a single line. The latter alternative seems the most likely explanation, since the float occurs at isolated points. Other deposits, some of them roughly parallel to this zone, also occur at different points on the claims.

The main showing lies on the Carrie claim about 400 feet southwest of the common corner of the four claims. At this point an open-cut has exposed a mass of galena, 12 feet 6 inches wide. The strike on the hanging-wall side is north 30 degrees east and on the foot-wall side it is north, both walls being approximately vertical. In a second cut 30 feet to the north-east, the ore-body is 4 feet wide and in a third cut some 50 feet northeast of the second, no ore was found. A section across the large showing from the hanging-wall to the foot-wall shows:

	Feet	Inches
Disseminated galena in quartz.............		6 to 10
Crushed quartz..........................		12
Massive galena, with tetrahedrite and blende.	5	
Quartz with disseminated galena...........	4	6
Massive galena.........................	2	6

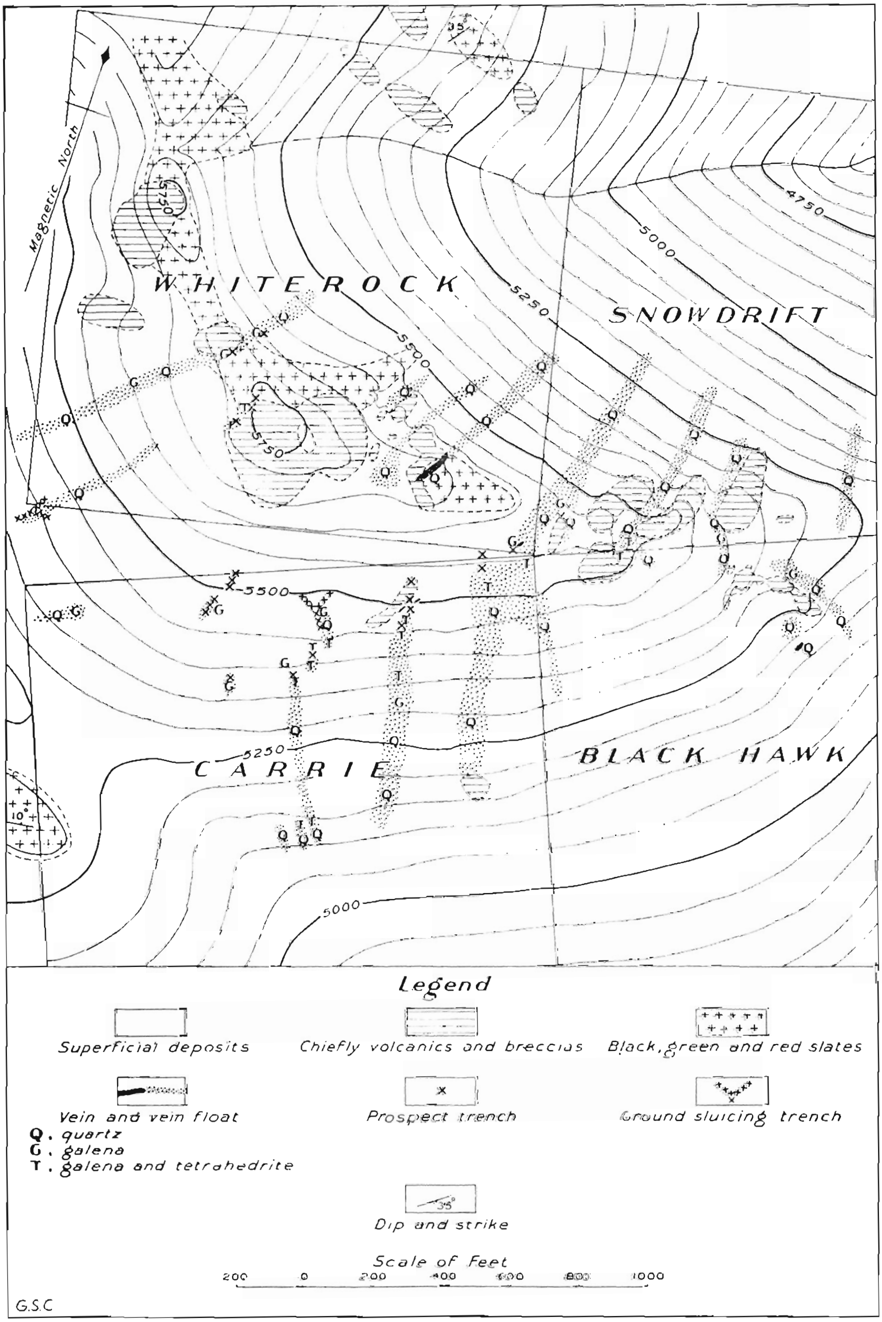

FIGURE 9. Principal claims on McKay hill, Mayo district, Yukon.

The galena in these cuts has a laminated or gneissoid texture, such as is common in other deposits in Mayo district. The laminæ pass around crystals of tetrahedrite, giving the appearance of an augen gneiss.

A sample, No. 4, was cut across the face of this body in the southwestern trench, from wall to wall over the full width of 12 feet 6 inches, and assayed 3·25 ounces of silver to the ton and 56·45 per cent lead. For the sake of comparison two assays, Nos. 18 and 19, of samples of the float from this vein taken during the summer of 1923, are added. These assayed respectively 45·0 and 14·0 ounces of silver to the ton and 59·45 and 78·20 per cent lead.

At the common corner of the four claims the most northeasterly outcrop of this zone occurs. Though only partly exposed, it apparently consists of a sheeted zone with the following approximate section from east to west.

	Feet
Quartz with disseminated galena	10
Leached and iron-stained greenstone	8
Quartz with some disseminated galena	4
Leached greenstone	10
Quartz with disseminated galena	3

Three samples were taken: No. 13 of the 3-foot vein; No. 14 of the central vein; and No. 15 of the 10-foot vein; of which the assay results are 4·00, 10·00, and 5·50 ounces of silver to the ton and 22·83, 44·00, and 39·38 per cent lead.

No outcrops other than those described above occur along the zone, but streams of float descending the hillside indicate where other mineralized portions occur, and by tracing the float upward to where it ceases the positions of the ore-bodies may be readily located. Two samples, No. 16 a picked sample carrying tetrahedrite, and No. 17 an average of the float, were taken the previous summer and the assays of these gave 62·1 and 17·80 ounces of silver to the ton and 9·57 and 63·40 per cent lead, respectively.

Veins or ore-bodies other than those belonging to the zone described occur as follows. Two large quartz veins, apparently barren, occur near the summit of McKay hill. To the north of the summit the existence of two veins is indicated by float. One of them occurs about 100 feet and the other 300 feet northwest of the summit. The first of these probably occurs at or near the contact of the greenstone mass forming the summit of McKay hill, with black slates. The vein has not been found in place, but apparently consists mainly of quartz, galena, and tetrahedrite. A sample, No. 11, taken of the float in 1923, assayed 13·20 ounces of silver to the ton and 54.00 per cent lead. The second vein presumably occurs in a small saddle at the contact of a smaller greenstone mass. Two trenches have been dug across the saddle, but neither of these reaches bedrock. The float, however, cannot be far from its point of origin. It consists chiefly of galena with a little tetrahedrite. A sample of the float, No. 12, taken the previous summer, assayed 11·00 ounces of silver to the ton and 44·95 per cent lead.

On the eastern end of the hill one vein outcrops on the Snowdrift claim about 200 feet to the east of the common corner of the four claims. It is only partly exposed, with the hanging-wall and 18 inches of the vein showing. Judging by the float, however, a streak of galena lies adjacent to the exposed part. The strike of the vein is north 5 degrees west magnetic and the dip 70 degrees to the southwest. The quartz lying along the hanging-wall is barren for a width of about a foot and carries vugs lined with large crystals; the remaining 4 to 6 inches exposed is well mineralized with tetrahedrite, azurite, and malachite. The covered part of the vein probably consists of quartz with galena. Two samples were taken; of these No. 9 is a picked sample of the tetrahedrite, and No. 10 is intended to represent the average of the vein material, both float and that in place. These showed 38·00 and 26·00 ounces of silver to the ton and 4·58 and 19·76 per cent lead.

Quartz float containing galena occurs in two places at the eastern end of the ridge around small greenstone masses, and probably indicates the occurrence of two other veins or lenses of ore, but no trenching has been done on these. Quartz float, apparently barren, crosses the eastern slope of the hill.

Adjoining the four claims described above are the Snowball, Big Windy, Wild Goose, and Eagle claims on the south, the Wild Duck and Bessie claims on the north, and the Tiger and Red Rock claims on the west. These claims may be considered as part of a group to which the four described belong. On the east and north of this group is the Yellow Rock group of six claims owned by A. N. Martin, O. Dahl, E. Anderson, and C. Williamsen. Mineral float has been found at several localities on this group, but the deposits from which it comes have not yet been located.

Horseshoe hill lies east of McKay hill, across from which it is separated by a small gulch known as Red gulch. The rocks exposed are similar to those of McKay hill, and the mineralization may be an extension of that of the McKay Hill area. In the saddle at the head of the right fork of Red gulch a large amount of vein float occurs, and a group of four claims, the Independence group, has been staked by A. N. Martin, O. Dahl, E. Anderson, and C. Williamsen. The float consists of quartz, galena, and tetrahedrite, but the deposit from which it comes has not been located. The assays of three samples, Nos. 6, 7, and 8, taken of this float in 1923, showed 1·00, 0·60, and 1·00 ounces of silver to the ton and 62·30, 42·36, and 29·15 per cent lead.

On the other hills surrounding McKay hill there is considerable evidence of mineralization. Large quartz veins occur on the hills on both sides of the head of Falls creek. The quartz outcrops where examined usually proved to be barren, but similar barren veins occur in the vicinity of the McKay Hill deposits. In one instance, on the Crystal claim of F. Envoldsen, on the western side of Falls creek and about 2,500 feet above the level of the creek, the quartz carries galena, chalcopyrite, and zinc blende, with limonite, probably derived from pyrite. The deposit has not been prospected to any extent.

The deposits of McKay hill and the surrounding hills are not sufficiently well exposed to permit of obtaining a good idea of their nature and genesis. As a general rule the deposits occur in, or at, the margins of the greenstone masses. The conditions on the southern face of McKay hill, where most work has been done, suggest the presence of a series of lenses of ore arranged along a line striking approximately north 30 degrees east, but it is impossible to say whether there is a continuous vein with oreshoots localized at the points where mineral has been found in place or as float, or whether there is a series of lenses entirely independent of one another. The discovery of particles of galena and tetrahedrite in the greenstone suggests the existence of a genetic connexion between this rock and the ore deposits. This conception is somewhat strengthened by the fact that calcite has been deposited in the amygdules of the greenstone, and has also replaced parts of the greenstone to form large masses of calcite. As far as is known the ore-bodies are confined to the greenstones and to their contacts with the Tindir slates, a fact that would further support the idea of a genetic relationship between the greenstones and the ore-bodies. If this theory be correct the individual ore-bodies cannot be of great size, as the greenstone bodies are themselves small.

Other Localities

A considerable amount of float consisting of galena, calcite, and siderite was observed on the southern end of Carpenter ridge, but no deposits were seen in place. The prospect pits made here in 1922 and 1923 have largely been filled in by slide rock. It is doubtful if any veins were uncovered by the pits. A grab sample, No. 5, was taken of the float and the assay gave 8·75 ounces of silver and 56·0 per cent lead.

On Elliott hill, on the Apex claim, staked by J. McCluskey in 1922, a quartz vein about a foot thick crosses the ridge a quarter of a mile north of the summit. The vein is exposed along the strike for a few feet only. Quartz forms the bulk of the vein-filling. Associated with it is some chalcopyrite and a little galena. The chief values would appear to be in copper. No sample was taken.

Galena has been reported to occur in the continuation of Beaver valley to the northwest 30 miles beyond the height of land.

Conclusions

None of the ores which to date have been located in place in Beaver River district are rich enough to permit of mining at a profit under existing conditions of transportation. At present the ores would have to be hauled overland to Stewart river a distance of 85 to 100 miles and shipped from there to smelters on the Pacific coast, distant some 3,000 miles by the route followed. When it is considered that the mining costs of the Keno Hill ores aggregate upwards of $100 a ton, and that these are situated 45 to 60 miles nearer to the shipping point than the Beaver River ores, and that the latter, on account of their remoteness, would have to bear correspondingly higher mining and shipping charges, it will be readily seen that mining of the Beaver River ores, if dependent upon shipping to outside smelters, is out of the question. If a railway to the coast were constructed mining might be carried on successfully, particularly if reduction works were erected in the district. These improvements could be justified only if a sufficient tonnage of ore were proved, a condition which does not yet obtain.

On the other hand galena has been found at many points over an area of several hundred square miles, and this with comparatively little prospecting. It is almost certain that with further work other deposits will be discovered, both within and beyond the area described. High-grade ore has not yet been found in place, but occurs as float, and it is quite possible that within the near future deposits of high-grade ore may be found such as would permit of profitable mining.

1925

Introductory Note

The following paragraph by G. A. Young, Chief Geologist, on field work in Yukon, 1925, is included in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1926, page 10:

"C. H. Stockwell, under the direction of W. E. Cockfield, made a detailed survey of the geology and silver-lead deposits of Galena Hill northeast of Mayo. A full account of these important deposits, accompanied by a detailed map, is presented in the Summary Report, 1925, Part A."

GALENA HILL, MAYO DISTRICT

by C. H. Stockwell

The discovery and exploitation in 1914-16 of the Silver King silver-lead deposit on Galena hill, Mayo district, was followed by prospecting which resulted in finding of other silver-lead deposits on neighbouring hills, those on Keno hill*, discovered in 1919, being the most important so far found in the Yukon. On Galena hill a considerable amount of staking and prospecting followed, but it was not until 1923 that the float was found which led to the discovery of an ore-body since shown by the mining operations of 1924 and 1925 to be of importance. This deposit, on the Arctic and Mastiff claims, has already produced about 375 tons of high-grade ore, and, at present, is the only productive property on Galena hill. Another property recently shipped a few tons of ore and several prospects have very good indications of the presence of high-grade ore.

The field work upon which this report is based occupied three months during the summer of 1925 and included the topographical and geological mapping, and the investigation of the mineral deposits of Galena hill. In this work J. E. Kania rendered very able assistance. The writer wishes to thank the miners and prospectors of the district, all of whom willingly gave much helpful information and assistance. The writer worked under the supervision of W. E. Cockfield to whom he is grateful for valuable suggestions and criticisms.

Galena hill is 120 miles east of Dawson and 27 miles in a straight line northeast of Mayo on Stewart river, a tributary of Yukon river. During the season of open navigation there is a regular steamship service on Stewart and Yukon rivers between Mayo, Dawson, and Whitehorse. Railway service between Whitehorse and Skagway, on the Pacific coast, is available the year round. In winter, Mayo may be reached by stage from Whitehorse.

A wagon road from Mayo passes along the base of the southeastern slope of Galena hill and continues to the town of Keno a mile farther on. At present an ungraded branch road connects several mineral claims on the upper northwest slope of the hill with the main road, and a somewhat shorter road with a better grade is being constructed for hauling ore to the main road. On the northwest side of the hill an old road, passing through the Silver King property, joins the Mayo road to the southwest.

*Cockfield, W. E., Geol. Surv., Canada, Sum. Rept. 1923, pt. A, pp. 1-21.

Topography

Galena hill is situated in the dissected Yukon Plateau province, which is mountainous with a relief of 1,500 to 4,000 feet or more. The hill has an elevation at its highest point of a little over 5,000 feet above sea-level and a relief of 2,800 to 3,000 feet above the surrounding valleys. It is about $4\frac{1}{2}$ miles wide and 8 miles long, the longer axis striking northeast. On the northwest it is bounded by the broad, flat-bottomed valley of the south fork of McQuesten river, on the northeast by Christal creek, on the southeast by Duncan creek, and on the southwest by Williams creek and a low, flat area through which Galena creek flows.

Except for a rock prominence at its highest point, the top of the hill is gently rolling and is grass or brush-covered. These gentle top slopes gradually change to steeper slopes on the sides of the hill, the change in slope being about at timber-line. Still steeper slopes, in part due to glacial erosion, occur on the lower parts of the hill.

Faulting has had an effect on the topography both by determining the location of some of the stream valleys and by causing the formation of escarpments. Examples of stream valleys localized by faulting are those of Galena creek, Brefalt creek, Porcupine gulch, and probably others; the valleys either closely follow, or occur at one side of the faults. An example of a fault scarp is found along a part of the northeastern slope of Porcupine gulch which has been eroded at the base of the scarp and obscures its presence. Other smaller fault escarpments also occur.

Minor irregularities in the topography are due to differences in resistance to erosion of different kinds of rock. Greenstone where surrounded by schist forms prominent knobs and ridges.

General Geology

The rocks of Galena hill consist of schist, quartzite, greenstone, and rhyolite. The greenstone, much of which is schistose, and the rhyolite intruded the schist and quartzite along planes of bedding and secondary cleavage. In general the cleavage of the schist and greenstone closely parallels the bedding of the quartzite. On the whole the bedding and cleavage strike slightly north of east* except on the part of the hill east of its highest point where the strike is slightly south of east; in detail the strikes vary as a rule between 35 degrees north and 35 degrees south of east. The average dip is about 30 degrees southerly, but the angle varies, for the most part, between 20 degrees and 40 degrees and is even as high as 75 degrees in the vicinity of faults.

The quartzites and schists form three, lithologically distinct stratigraphical units: a lower schist member; a middle quartzite member; and an upper schist member. The three units apparently are conformable and within the map-area have a monoclinal dip.

The *lower schist member* occurs along the lower part of the northern, and part of the northwestern, slopes of the hill. It consists mainly of grey, black, and green schists containing variable amounts of quartz, mica, graphite, and chlorite. Thin beds of quartzite are in places interbedded with the schist. A light green, quartz-mica-chlorite schist is characteristic of the upper part of this schist member.

*All directions referred to in this report are astronomic.

The *middle quartzite member* outcrops along the northwest slope, the summit at the northeast end, and the northeast slope of the hill. It consists dominantly of a massive, grey and white quartzite which in places contains a considerable amount of mica and has a gneissoid appearance. Under the microscope the quartz is seen to be recrystallized and, in addition to the mica, minor amounts of graphite, epidote, and pyrite are present in some cases. Minor amounts of quartz-mica schist and quartz-graphite schist occur interbedded with the quartzite. Locally the quartzite is calcareous. In its upper part the quartzite is for the most part less massive and has a banded appearance; it contains a considerable amount of mica and graphite. Interbedded with this banded quartzite is much quartz-graphite schist.

The *upper schist member* occupies a large area on the southern half of the hill. It consists largely of grey and yellow quartz-mica schists. Quartz-graphite schist and quartzite are quite abundant locally and minor amounts of crystalline limestone and chlorite schist also occur. The lower part is generally characterized by a quartz-mica schist containing rounded particles of quartz readily visible to the naked eye. The microscope shows in addition a few rounded grains of orthoclase, acid plagioclase, and rock fragments.

The middle quartzite, lower schist, and upper schist are correlated with a part of the Nasina series of Klondike district described by McConnell[1] and referred by Cairnes[2] to the Precambrian. The strata on Galena hill are believed to be largely of sedimentary origin.

Greenstone intrudes the quartzite and schists. It occurs chiefly in the lower schist member, and to a less extent in the quartzite, but is almost entirely absent from the upper schist. In the lower schist area it forms irregular, discontinuous masses elongated in a direction approximately parallel to the schistosity. In the quartzite it has been intruded along bedding planes and has formed bodies of fairly uniform character. The greenstone is much altered. It probably represents andesite and related rock types. It contains hornblende, altered feldspar, and a small amount of original quartz and titanite; alteration products include quartz, chlorite, and calcite. Locally it contains much biotite and a considerable amount of quartz. The greenstone is both massive and schistose. It is younger than the schists and quartzite, and is probably earlier than the rhyolite.

The rhyolite was intruded as a thin sill along parts of the contact between the quartzite and the upper schist member. It is a fine-grained, non-schistose rock composed of quartz, acid plagioclase, altered orthoclase, mica, calcite, and a little chlorite. The rhyolite is probably younger than the greenstone, for, although its relation to the greenstone was not determined on Galena hill, similar acid rocks cut greenstone on Keno hill[3]. The rhyolite may be an offshoot from a granite of, probably, Jurassic or Cretaceous, but possibly Tertiary, age. Although the granite was not found on Galena hill it outcrops at several localities in Mayo district and probably underlies much of the area.

The quartzite and probably at least the major part of the schist were

[1] McConnell, R. G.: "Report on the Klondike Gold Fields"; Geol. Surv., Canada, Ann. Rept., vol. XIV, pt. B, pp. 12-15 (1901).

[2] Cairnes, D. D.: "The Yukon-Alaska International Boundary"; Geol. Surv., Canada, Mem. 67, pp. 38-44 (1914).

[3] Cockfield, W. E.: "Silver-lead Deposits of the Keno Hill Area, Mayo District, Yukon"; Geol. Surv., Canada, Sum. Rept. 1920, pt. A.

originally sediments which with the greenstone bodies have been folded to their present attitude and metamorphosed to quartzite and schist. The folding has resulted in general dips to the south and the local formation of crenulations and drag-folds in beds of limestone and impure quartzite. The axial planes of the drag-folds strike northeast and dip southeast, indicating that during the folding the upper beds moved northwest relative to the lower beds.

All the consolidated rocks have been faulted. Since the faults are closely related to the mineral deposits, they are described under the heading of economic geology. Many joints are present, particularly in the quartzite, greenstone, and rhyolite.

Glacial deposits are thick on parts of the lower slopes, but are generally thin on the upper slopes and top of the hill. The ice moved southwesterly and on the top of the hill it scattered quartzite boulders over the schist to the southwest. The quartzite boulders are abundant near the contact between the quartzite and upper schist and gradually become less abundant to the southwest. Most of the bedrock is covered by rock float, talus, vegetation, and glacial deposits, but the character of the underlying rock may in many cases be judged by the nature of the float. Rock in place is well exposed in deep gulches, but outcrops are as a rule scarce elsewhere; quartzite and greenstone are better exposed than schist.

Economic Geology

The mineral deposits of Galena hill are fissure veins in which the ore occurs chiefly in shoots. The veins follow faults which, with a few exceptions, strike northeasterly and dip steeply to the southeast. Other northeasterly-striking faults, which are not known to be mineralized but warrant prospecting, have also been mapped. Northwest faults occur also, some of which are apparently later than and offset the northeast faults; these later faults are not known to be mineralized.

The faults as a rule are not easily recognized in the field. Fault-planes are rarely exposed except in artificial excavations. Observed fault-planes, if not too much altered by weathering, are slickensided surfaces with steeply dipping striæ. Where not exposed, faults are inferred to be present where formations are offset along their strike, such evidence being supported in many places by an abrupt difference in strike or dip of bedding planes on opposite sides of the fault or by the presence of an escarpment along the fault.

The faults probably are not as simple as indicated on the map, and some that are shown as single faults may actually be zones of faulting complicated by cross-faults. Many faults in addition to those mapped no doubt also occur.

The following minerals occur in the deposits:

Native elements.......	silver, gold
Sulphides.............	galena, sphalerite, pyrite, arsenopyrite, chalcopyrite, marcasite, pyrrhotite, stibnite
Sulpho-salts...........	freibergite, pyrargyrite
Oxides.................	quartz, chert, limonite, manganese oxide
Carbonates............	siderite, ankerite, calcite, cerussite, malachite, azurite
Silicates..............	white mica

The veins have been classified on a mineralogical basis into four groups, as shown below. The classification of any particular deposit is tentative, for further development work will undoubtedly lead to more knowledge of the character of the veins. There are no sharp dividing lines between the different groups of deposits, but taken as a whole each group has certain fairly definite characteristics.

Summary of Mineralogy, Strikes, and Dips of the Known Veins on Galena hill: *, *surface trace;* X, *of major importance;* x, *of minor importance*

		Native elements		Sulphides								Sulpho-salts		Oxides				Carbonates						Silicates				
Group	Name of property	Silver	Gold	Galena	Sphalerite	Pyrite	Arsenopyrite	Chalcopyrite	Marcasite	Pyrrhotite	Stibnite	Freibergite	Pyrargyrite	Quartz	Chert	Manganese oxide	Limonite	Siderite	Ankerite	Calcite	Cerussite	Malachite	Azurite	White mica	Silver values	Gold values	Strike of vein	Dip of vein
I	Arctic and Mastiff	..	..	X	..	x	..	..	..	..	..	x	..	x	..	X	X	X	..	..	X	..	..	..	X	..	N. 12° E. N. 48° E. N. 27° E.	67° SE.
	Ruby Fraction	..	..	X	..	x	..	..	..	..	..	?	..	..	..	X	X	X	..	..	X	..	..	..	X	..	N. 55° E.	67° S.E.
	Coral and Wigwam (main vein)	x	..	X	..	x	..	..	..	..	..	X	..	x	..	X	X	X	..	..	X	..	..	..	X	..	N. 53° E.	70° SE.
	Elsa	..	..	X	..	x	..	x	..	..	..	X	..	x	..	X	X	X	..	..	X	x	x	..	X	..	N. 45° E.	70° NW.
	Dragon (main vein)	..	..	X	..	..	..	..	..	..	..	X	..	x	..	X	X	X	..	..	X	..	..	..	X	..	N. 16° E.	66° SE.
	Hector	..	..	x	..	..	..	..	..	..	..	..	..	..	..	X	X	?	..	..	X	..	..	..	X	..	N. 48° E.	65° SE.
	Dixie (siderite float)	..	..	..	..	x	..	..	..	..	..	..	..	..	..	X	X	X	..	..	..	..	..	..	..	..	....	....
II	Silver King vein	..	..	X	X	X	..	x	x	..	..	..	X	X	x	X	x	X	x	..	X	..	..	..	X	x	N. 68° E.	55°-80° SE.
	Rico	..	..	..	..	x	..	..	..	..	..	..	..	x	..	X	x	?	x	..	..	..	..	..	..	..	NE.	SE.
	Bluebird	..	..	X	X	x	..	..	..	..	..	..	..	x	..	x	x	..	X	x	x	..	..	..	X	..	N. 25° E.	62°SE.
	Tin Can	..	..	x	x	x	..	..	..	..	..	..	..	x	..	x	x	x	X	x	..	..	..	..	..	..	N. 50° E.	SE.
	Eagle	..	..	X	x	X	..	..	..	..	..	..	..	X	..	..	x	x	..	..	..	x	..	..	..	..	N. 50° E.	SE.
III	Jupiter	..	x	..	x	X	X	..	..	..	..	..	..	X	..	..	x	..	X	x	..	..	..	x	x	x	N. 53° E.	80° SE.
	Betty	..	..	X	X	..	x	..	..	x	..	..	..	X	..	..	x	..	..	X	x	..	..	..	x	..	N. 58° E.	SE.
	Crystal King	..	..	x	x	x	X	..	..	..	..	..	..	X	..	..	..	..	..	..	..	..	..	..	x	x	N. 74° W.	60° NE.
	Dragon (cross vein)	..	..	x	..	X	X	..	..	..	..	..	..	X	..	..	..	..	..	..	..	..	..	..	..	x	N. 82° W*	....
	Dixie (quartz vein)	..	..	..	..	..	x	..	..	..	..	..	..	X	..	..	..	..	..	..	..	..	..	..	..	..	E.-W.	40° S.
IV	Coral and Wigwam (stibnite vein)	..	..	..	..	..	..	..	..	..	X	..	..	X	..	..	..	..	..	..	..	..	..	..	x	..	....	....

(I) The veins of group No. I may be called siderite-galena-freibergite veins. Manganiferous siderite is by far the most important gangue mineral; galena and freibergite are the most important ore minerals. The chief minerals formed by weathering of the gangue and ore minerals are cerussite, limonite, and manganese oxide, the last causing conspicuous blackening in the oxide zone. Quartz and pyrite are present as a rule, but only in very small quantity. Chalcopyrite, malachite, and azurite were found only in small amounts in one deposit. Native silver is reported to have been found near the surface of one deposit. Silver values are mostly high, although not always in sufficient amount to make mining profitable. Gold values are absent or unimportant.

The vein at the only mine in operation on the hill at present and those of most of the encouraging prospects have this type of mineralization.

(II) A considerable variety of deposits are included in group No. II. The predominant gangue mineral is either quartz or ankerite; calcite is present in a few places and siderite is either subordinate or absent. Although the ankerite generally carries manganese, the black manganese oxide, so characteristic of the oxide zone of the veins of group I, is less conspicuous in most, although not all, of these deposits. Both galena and sphalerite were noted in all except one deposit; pyrite is always present and occurs in important amounts in some cases; limonite, cerussite, chalcopyrite, and malachite are also present. Silver values are important in some of the deposits.

One deposit, the Silver King vein, mined chiefly during the years 1914-16, does not closely resemble any other known deposit on the hill in that it contains an important amount of ruby silver, smaller amounts of marcasite and chert, and was a rich silver-lead deposit in a gangue consisting mainly of quartz. Small values in gold were also present.

The Silver King vein has in the past been an important producer and some of the other deposits in this group are encouraging prospects.

(III) The veins of group No. III may be called quartz-arsenopyrite veins. Quartz is the chief gangue mineral, but ankerite, calcite, and a minor amount of white mica are present in some veins. Arsenopyrite is characteristic; pyrite, galena, and sphalerite are present in most cases; pyrrhotite occurs in one deposit and a speck of native gold was found in another. Cerussite and limonite are present as alteration products. The veins as a rule contain small values in both gold and silver.

Deposits of this type on Galena hill have not yet shown promise of being of economic importance.

(IV) Group No. IV is represented by one unimportant quartz-stibnite deposit said to carry low silver values.

The age of the faults of group III (the quartz-arsenopyrite veins) on Galena hill has not been determined, but on Keno hill, which lies to the northeast, it has been determined that veins mineralized with quartz, arsenopyrite, and pyrite are older than veins mineralized chiefly with siderite, freibergite, galena, and sphalerite*. The general similarity in the geology of the two hills suggests that on Galena hill the veins of group III may be older than those of groups I and II. The age relation between the veins of groups I and II is not known. The northwest faults not known to be mineralized are believed to be the youngest faults, for they apparently offset the veins of the above groups.

The strikes of the veins of the different groups vary between the limits shown below. The limiting directions of the surface traces of northwest faults not known to be mineralized are included for comparison; the

*Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1923, pt. A, p. 4.

true strikes of these are not known, but they probably approximate the direction of the trace.

Surface traces of northwest faults not known to be mineralized	N. 72° W. to N. 21° W.
Veins of group I	N. 12° E. to N. 55° E.
Veins of group II	N. 25° E. to N. 68° E.
Veins of group III*	N. 53° E. to S. 74° E.

There is an overlapping of the strikes of the veins of the different groups, as classified on a mineralogical basis, and a marked variation in the strike of the veins of any one group. Regardless of this overlapping and variation the strikes of veins now known are on the whole different in different groups. Those of group III, probably the oldest, approach most closely the general strike of the rocks, which is slightly north of east; those of groups I and II, which are probably intermediate in age, strike more northeasterly; and the youngest faults, which are not known to be mineralized, strike northwesterly.

The bedrock strikes slightly north of east and dips southerly less steeply than the veins. All the veins of group I occur in the quartzite; some of those of groups II and III occur in the quartzite and the rest in the lower schist and intruded greenstone. No veins are known to occur in the upper schist.

The veins cut the greenstone and are probably closely related in age to the rhyolite. It is thought that both the material of the veins and the rhyolite had their origin in a granite mass which is believed to underlie much of the district. Granite occurs at the surface to the east, northeast, northwest, and southwest of Galena hill at distances of 18, 10, 14, and 25 miles respectively, and at other places in Mayo district. The granite is probably contemporaneous with the Coast Range intrusives, which in the Yukon may range from Jurassic to well into Cretaceous time**. The veins were formed during the later stages of the consolidation of the granite.

In prospecting for silver-lead veins it has been found that float of black manganese oxide or galena is a valuable indication of the presence of a vein. The prospector follows the float up hill and looks for a vein near the upper limit of the float under the superficial covering, which is removed by means of open-cutting or ground-sluicing. It should be borne in mind that the ice-sheet which moved southwesterly may have distributed some float up hill from the veins; however, this has not been an important factor and most of the float is found on the slope below the vein. If the float is fairly abundant and occurs at or near the surface it is likely to be derived by down-slope creep from the veins; if it occurs in scattered masses in the drift it is likely to have been transported by the ice-sheet. Prospecting is difficult because of the frozen nature of the ground. Ground-sluicing with snow water, in the spring, is extensively used for removing the overburden. The quartzite and large greenstone areas appear to be the most favourable for the occurrence of wide, persistent veins.

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*The strikes of two non-persistent stringers have been omitted.

**Cairnes, D. D.: Geol. Surv., Canada, Supplement to Mem. 31 (from Sum. Rept. 1915), p. 42.

Description of Properties

Arctic and Mastiff Claims

The claims are at present the most important on the hill and during the summer of 1925 were the only ones being mined. They are situated high on the northwestern slope of Galena hill near the head of Star creek. The owners are C. R. Settlemier, C. H. Bermingham, S. M. Dorr, and A. Stoner.

The claims were staked in 1921. In 1923 float was found which led to the discovery of the present mine. In the spring of 1924, 26 tons of ore was shipped and in September, 1925, about 350 tons of ore was sacked ready for shipping the following winter. A much larger tonnage may be expected in the future. The ore is hand-sorted before sacking for shipment. The owners state that the sacked material averages approximately $200 to the ton, and carries about 62 per cent lead and 150 ounces or more of silver to the ton.

A shaft, inclined 67 degrees to the southeast, has been sunk to a vertical depth of 46 feet and a drift run for 100 feet along a vein. The floor of the drift is 38 feet below the collar of the shaft. Other workings consist of a prospect shaft and about twenty-five open-cuts.

A small amount of ore was found near the surface in sinking the main shaft, in the prospect shaft, and in some of the open-cuts, but the main ore-body was opened up along the drift. The drift is along what appears to be the top of a tabular ore-shoot, the limits of which are as yet unknown. The part mined out was at least 90 feet long and averaged at least 5 feet in width, but in some places was as much as 9 feet wide. The depth is unknown. Approximately 3,500 cubic feet of the material mined, which is highly porous, yielded after sorting, 350 tons, a ratio of 10 cubic feet of ore in place to one ton of sorted ore. The hanging-wall of the ore-shoot as a rule dips 67 degrees southeast; the foot-wall is at a steeper angle. The strike is variable, due to an abrupt difference in trend in the central part, the northeast half striking north 12 degrees east and the southwest half striking north 48 degrees east. The country rock is quartzite with some mica and graphite schist, the schist apparently being more abundant on the hanging-wall.

The minerals in the vein are galena, cerussite, and freibergite in a gangue of limonite, manganese oxide, siderite, and a very small amount of quartz and pyrite. The galena, which contains sparsely distributed blebs of freibergite, occurs in irregular masses, but more typically in bands parallel to the strike and dip of the ore-shoot. Due to movement along the vein the galena is generally gneissoid, particularly near the hanging-wall. It is coarse-grained, fine-grained, and 'steel'; the latter variety occurs as a rule in small amounts close to the hanging-wall and is said to contain higher silver values. The most abundant primary minerals of the deposit are galena and manganiferous siderite. Due to oxidation, hydration, and leaching by surface waters the siderite has been almost completely altered to limonite and manganese oxide, with the development of much pore space and many small cavities. The galena has been much more resistant and is generally fresh, although on exposed surfaces it is altered to earthy cerussite. Cerussite also occurs as small crystals loosely adhering to the walls of cavities in limonite, manganese oxide, and galena. During the summer, waters percolate freely through certain channels in the deposit, but some of the cavities are filled with ice.

The vein probably has been offset by a northwest fault. The part of the vein described above appears to lie on the northeast side of the fault and to be offset to the southeast relative to the part of the vein on the southwest side of the fault. This latter part of the vein, which strikes north 27 degrees east and dips steeply to the southeast, has been exposed by a prospect shaft, mentioned above, and open-cuts. The material on the dumps indicates that the vein is mineralized for a length of 300 feet from the fault with limonite, manganese oxide, and a small amount of quartz and pyrite; a little galena and cerussite were also found.

Ruby Fraction

This property, a small fraction owned by E. Bjonnes, is situated on the northeast side of the Mastiff claim.

A vein, $1\frac{1}{2}$ feet wide, striking north 55 degrees east and dipping 67 degrees southeast, was prospected during the summer of 1925 by means of two open-cuts. The country rock is mainly quartzite with some mica and graphite schist. The vein is mineralized with siderite, galena, a small amount of pyrite, and probably freibergite. Alteration products are limonite, manganese oxide, and cerussite. According to information supplied by the owner, the galena carries from 250 to 385 ounces of silver to the ton and earthy cerussite carries as high as 700 ounces of silver to the ton.

Coral and Wigwam Claims

This property, part of a large block of claims owned by R. Fisher and Dr. W. E. Thompson, is situated at the head of Porcupine gulch on the northwest slope of Galena hill. The claims were staked in 1921, but the main work on the property was done in 1924. The owners state that 7 or 8 tons of ore, assaying 258 ounces of silver to the ton and 61 per cent lead, were shipped. No mining was done on the property during the summer of 1925.

The workings consist of a few open-cuts and three shafts along the strike of a vein. The centre shaft is 26 feet deep and from the bottom a drift has been run a short distance northeast along the vein; from near the end of the drift a short crosscut was driven southeast. The other shafts were filled with water at the time of the writer's visits. On adjoining claims belonging to the same owners, three ditches, two of which are shown on the map, were dug during the summer of 1925 in preparation for ground-sluicing in the following spring.

The centre shaft, drift, and crosscut are in a shear-zone striking north 53 degrees east and dipping 65 to 75 degrees southeast. The foot-wall is mica and graphite schist and the hanging-wall is chiefly quartzite with some schist. Mineralization is irregular and occurs chiefly near the foot-wall of the shear zone. The primary minerals are galena, associated with a considerable amount of freibergite, in a gangue of siderite and minor quantities of quartz and pyrite. Alteration products observed are limonite, manganese oxide, and cerussite. It is reported that native silver occurred near the surface at the shaft.

Similar gangue minerals and their alteration products were observed on the dumps of the other two shafts, and in addition to these minerals a little galena was seen at the northeast shaft.

Just northwest of the latter shaft brecciated quartzite is mineralized with quartz and stibnite. The deposit is said to carry only low values in silver.

Elsa Claim

This property, owned by C. Brefalt and D. Tolmie, is situated low down on the south side of Porcupine gulch. In the spring of 1925 a vein was exposed by means of ground-sluicing and was further prospected by an open-cut.

The country rock is quartzite with some graphite schist. The mineralization occurs in a fault which strikes north 45 degrees east and where exposed in the open-cut dips 70 degrees northwest. At this point the walls are poorly defined, but the vein may be as much as 7 feet wide. The primary minerals present are siderite, galena, which is partly gneissoid and partly undisturbed, freibergite, and minor quantities of quartz, pyrite, and chalcopyrite; alteration products include limonite, manganese oxide, cerussite, malachite, and azurite. The vein material occurs in part as a cement of quartzite breccia. The owners stated that samples of galena from the deposit assayed from 69 to 82 per cent lead and from 150 to 446 ounces of silver to the ton and that a sample of siderite and freibergite assayed 1,480 ounces of silver to the ton.

The fault probably extends for a considerable distance northeast and southwest from this open-cut. The presence of float vein material on the crest of the northern slope of Porcupine creek and in line with the strike of the vein indicates that the fault is mineralized at this point also.

Dragon Claim

This property, owned by O. Miller, is situated on the northern slope of the hill about a mile northeast of the highest point. During the past four years a great deal of work has been done on the property. A vein has been prospected along its strike for a distance of 500 feet by means of three shafts, 20, 24, and 42 feet deep respectively, five open-cuts, and two sluices. Many open-cuts and two sluices have also been made to the northeast of the main workings.

The vein, which is reported to be from 5 to 7 feet or more in width, strikes north 16 degrees east and dips 66 degrees southeast. The hanging-wall is quartzite and the foot-wall in most places black schist. The minerals in the vein are siderite, limonite, manganese oxide, galena, cerussite, freibergite, and a little quartz. The ore minerals carry high values in silver, but are only sparsely distributed through the siderite, which is the main constituent of the vein.

Near the northeast end of the vein the siderite ends abruptly and the mineralization is quartz, arsenopyrite, galena, and pyrite. Assays are said to show some gold values. It is assumed that this mineralization is in a cross-fault, the surface trace of which strikes north 82 degrees west. It is not known whether the fault is older or younger than the siderite vein.

To the northeast of this cross-fault and along the strike of the siderite vein there is apparently a brecciated quartz vein, but no siderite has been found. In a ground-sluice 950 feet northeast of the end of the siderite vein some galena float is present.

Hector Claim

This property, owned by C. Sinyard and M. S. McCown, is situated just west of the highest part of Galena hill.

A vein, which strikes north 48 degrees east and dips 65 degrees south east, was exposed during the summer of 1925 by means of two open-cuts. The country rock is quartzite, graphite schist, and greenstone, the last being exposed in one of the open-cuts on the hanging-wall of the vein. The vein, where exposed, is from 4 feet 3 inches to 5 feet wide. The material filling the vein is mostly limonite and manganese oxide which are probably alteration products of siderite. Cerussite and a little galena are also present. According to the owners the silver values are as high as 312 ounces to the ton, are carried chiefly in cerussite, and are as a rule highest near the hanging-wall. Part of the vein filling, particularly along the foot-wall, is quartzite breccia cemented by siderite. A band of soft quartz flour occurs along the hanging-wall.

Dixie Claim

This claim, owned by J. V. Sullivan, is situated on the northwestern slope of Galena hill; the workings are at an elevation of about 3,900 feet and are 2,000 feet northeast of Porcupine gulch.

The country rock is quartzite intruded by a sill of greenstone. In two open-cuts in quartzite 300 feet north of the greenstone some siderite float has been found. The siderite contains a little pyrite and is partly altered to limonite and manganese oxide.

In an open-cut near the greenstone a quartz vein sparsely mineralized with arsenopyrite is exposed. It strikes roughly east-west and dips about 40 degrees south.

A ditch has been dug in preparation for ground-sluicing in the spring of 1926.

Silver King, Mabel, Adam, and Webfoot Claims

The Silver King property is situated on Galena creek west of Galena hill proper. Although it is not being mined at present it was a producer of importance, particularly during the years 1915 and 1916. Over 2,500 tons of high-grade ore has been shipped.

The property was examined in 1915 by D. D. Cairnes who gives its early history as follows*. "The Galena Creek vein is believed to have been discovered and staked by H. W. McWhorter and partner about the year 1906, but the claim was afterwards allowed to lapse. The deposit was relocated in 1912 or 1913 by Mr. McWhorter who gave a lay on the ground to Jack Alverson and Grant Hoffman. These layers did the first real development on the property, and proved it to be of importance. They shipped 59 tons of ore to the smelter at Trail, B.C., the smelter returns for which amounted to $269 a ton, in gold, silver, and lead, the gold being very low, but the lead amounting to 45 per cent. In the spring of 1914 the property was acquired by Thomas P. Aitken and Henry Munroe, Mr. Aitken being the principal owner. During the winter of 1914-15 these owners shipped 1,180 tons of ore to San Francisco. The smelter returns for this shipment, according to a statement kindly furnished by Mr. Aitken, included $3 a ton in gold, and for about half of the ore, 39 per cent lead and 280 ounces of silver, and for the other half 23 per cent lead and 260 ounces of silver per ton." Mr. Aitken continued the mining until the spring of 1916. Later an option was secured by E. J. Ives and F. Manley who did some drilling on the property.

The vein has a known length of 2,400 feet, strikes north 68 degrees

*Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1915, pp. 27-29.

east, and dips steeply southeast. The country rock on the foot-wall side of the vein is massive quartzite and on the hanging-wall side is interbedded schist and quartzite. According to information kindly supplied by Mr. Alverson, the ore mined from the Silver King property occurred mainly in a shoot which pitched northeast along the vein. The shoot had an horizontal length of about 60 feet and was mined to a depth of 200 feet from the surface. The southwest end was 60 feet below the surface. The shoot averaged about 3½ feet wide and had a maximum width of about 7 feet. The minerals present were chiefly galena and ruby silver in a quartz gangue; cerussite, sphalerite, iron sulphide, and siderite also occurred. In the bottom of the ore-shoot iron sulphide and sphalerite were the predominant minerals.

At the time of the writer's visit the workings were inaccessible, but material on the mine dump, which had been obtained chiefly from the lower workings, was examined and found to contain pyrite, marcasite, sphalerite, galena, quartz, siderite, and minor amounts of pyrargyrite, chalcopyrite, chert, and manganese oxide. For further details of the deposit the reader is referred to the above-mentioned report by Cairnes.

The vein continues southwesterly from the Silver King property through two claims, the Mabel, owned by W. J. Tormey, and the Adam, owned by M. Evans. Material on the dumps of shafts sunk in the vein include siderite, ankerite, limonite, quartz, galena, and pyrite; both the siderite and ankerite are as a rule blackened with manganese oxide. No important ore-bodies have been found on these two claims, although a few tons of ore are said to have been shipped from the Adam claim.

Northwesterly from the Silver King claim the vein has apparently not been found. On the Webfoot claim, which is owned by J. Alverson and is the first claim to the northeast of the Silver King property, some manganese oxide and a small amount of pyrite were found on the dump of a prospect shaft; this shaft, however, lies northwest of the prolongation of the strike of the vein. The northeast extension of the vein has possibly been offset to the south by a cross-fault which occurs higher up on Galena creek; this conclusion is supported by the fact that ruby silver float is reported to have been found to the south of the strike of the vein in a ground-sluice on the Webfoot claim.

Rico Claim

This claim is situated on the eastern slope of Galena hill near Christal lake. It is owned by H. A. Stewart.

The workings consist of a ditch, shaft, and tunnel. The shaft exposes a vein in a zone of brecciated quartzite. The vein probably strikes northeasterly. The minerals observed by the writer are limonite, manganese oxide, a little ankerite, and very minor amounts of quartz and pyrite.

Bluebird Claim

This claim, owned by A. McLeod, H. Rhor, and S. Turpin, is situated low down on the northeast slope of the hill. A vein striking north 25 degrees east and dipping 62 degrees southeast was exposed during the spring of 1925 by means of two open-cuts. The vein is mineralized with galena, sphalerite, and pyrite in a gangue of ankerite, calcite, quartz, limonite, and manganese oxide. The country rock is greenstone and along the foot-wall it contains disseminated pyrite. The galena is reported by the owners to assay 292 ounces of silver to the ton and 77 per cent lead.

Tin Can Claim

This claim, owned by A. McLeod, H. Rhor, and S. Turpin, is situated low down on the eastern slope of the northeast end of Galena hill. The workings consist of a ground-sluice, two shafts, and a few open-cuts. The shafts have exposed a vein which strikes about north 50 degrees east and dips steeply southeast. Judging from the material on the dumps, the vein is mineralized with ankerite, calcite, quartz, sphalerite, pyrite, and a small amount of siderite, limonite, and manganese oxide. A small amount of galena is reported to have been found also. The owners report that the two shafts, which were filled with water at the time of the writer's visit, are 32 and 15 feet deep, that in the deeper shaft the vein is well-defined and about 3 feet wide, and that the hanging-wall is greenstone and the foot-wall is schist.

Eagle Claim

This claim, situated on the eastern slope of Galena hill at the head of McLeod creek, is owned by A. McLeod, S. Thurbur, and Miss J. Stewart.

A vein which strikes about north 50 degrees east and dips steeply southeast has been prospected by means of several open-cuts, prospect shafts, and ditches. On the northwest side of the vein the country rock is largely green and yellow mica schist and graphite schist; on the southeast side the country rock is quartzite. Judging from the material on the dumps the vein is mineralized with quartz, siderite, pyrite, galena, sphalerite, limonite, and malachite.

Jupiter Claim

This claim, owned by R. Fisher, is situated at an elevation of about 2,900 feet just west of Sandy creek on the northwest slope of Galena hill.

An open-cut in greenstone exposes a small vein which strikes north 53 degrees east and dips 80 degrees southeast. The minerals present in the vein form bands parallel to the walls of the vein and include quartz, ankerite, calcite, limonite, pyrite, arsenopyrite, sphalerite, and a little native gold and white mica. Small values in both gold and silver have been reported.

Betty Claim

This claim is situated at an elevation of about 3,700 feet just east of Sandy creek on the northwest slope of the hill. It is owned by A. Wightman.

Two small open-cuts in greenstone have exposed a narrow vein which strikes about north 58 degrees east and dips to the southeast. The minerals present are quartz, calcite, galena, sphalerite, arsenopyrite, pyrrhotite, cerussite, and limonite. The owner states that near the top of one of the open-cuts the chief ore mineral was galena; at greater depth sphalerite was most abundant and in the bottom some pyrrhotite was found. These changes took place in a vertical distance of only 3 or 4 feet.

Christal King Claim

This claim, situated on Christal creek at the foot of the northern slope of Galena hill, is owned by F. Swanson, O. Dahl, A. E. Erickson, and M. Evans.

The workings, which are now caved, appear to be entirely in schist.

The property was described in 1918 by W. E. Cockfield* who states that there are five arsenopyrite-gold quartz veins which, owing to the fact that they are thin and not very persistent, are not likely to prove of economic value. One of these veins or stringers strikes north 54 degrees west and is vertical; another strikes north 20 degrees west, and dips 50 degrees south-west. There is also a shear-zone 3 feet in thickness; it strikes north 74 degrees west and dips northeast at an angle of 60 degrees. Scattered irregularly through the rock of the shear-zone are small bunches of quartz, galena, arsenopyrite, pyrite, and sphalerite. Small values of silver and gold occur both in the veins and in the shear-zone. For further details the reader is referred to Cockfield's report.

*Geol. Surv., Canada, Sum. Rept., 1918, pt. B, pp. 9-10.

1926

Introductory Note

The following paragraph, relative to field work in the Yukon in 1926, by G. A. Young, Chief Geologist, appears in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1927, page 14:

"W. E. Cockfield explored geologically and geographically a large area near Aishihik Lake that includes a part of the eastern edge of the Coast Range batholith in southwestern Yukon. The relation of the batholithic body to ore deposits in Yukon and British Columbia has long been recognized. The field work in 1926 completed the mapping of all the more easily accessible parts of the eastern margin of the batholith in Yukon. A map and report representing the season's field work appear in Summary Report, 1926, Part A."

AISHIHIK LAKE DISTRICT

by W. E. Cockfield

The importance of the Coast Range batholith in connexion with ore deposits has been recognized in British Columbia and the adjacent parts of Yukon. In Yukon and the northern fringe of British Columbia, for instance, the mineral deposits of Atlin, Windy Arm, Wheaton, Whitehorse, Rainy Hollow, and Aishihik Lake districts all have a close genetic connexion with the batholith, or with underlying bodies of granodiorite which are closely related to the batholith. It has become increasingly apparent that a zone following the eastern contact of the batholith is an exceptionnally favourable place to prospect, and with this in view, the program of work in Yukon, during the past few years, was to delimit the eastern margin of the intrusives along the more accessible parts of the contact, linking up the work of previous investigators. This work was started in 1922, and has been continued at intervals. In 1924 a map of Whitehorse district, comprising the results of several seasons work, as well as the areas mapped by several previous workers, was completed, and is now available.

Field work in 1926 was in continuation of this general plan. The area chosen was Aishihik Lake district, which lies immediately west and north of Whitehorse district. The mapping of this area completes the outlining of the batholith between Whitehorse district and Lake Kluane district, and practically finishes the mapping of the eastern contact of the batholith from the British Columbia boundary northwest to lake Kluane; thus finishing the mapping of all the more readily accessible parts of the eastern margin of the batholith in Yukon.

The area mapped lies between latitudes 60° 45′ and 61° 30′ and between longitudes 136° 00′ and 137° 30′ west. It is located north and west of Champagne, on the Whitehorse-Lake Kluane wagon road, about 65 miles from Whitehorse. This road served as a base, the surveys being carried north from it for the necessary distances. The Dalton trail, which leads north from Champagne to Selkirk on Yukon river, crosses part of the map-area, and as sections of this trail are in fair condition all the area is readily accessible. A further means of entry into this district is a trail, in rather poor condition, from the Whitehorse-Dawson wagon road at the 52-mile post, to Hutshi village, where it connects with the Dalton trail.

A rapid triangulation was carried over the district, tying in with Whitehorse and stations of the Whitehorse sheet. Plane-table surveys were made along selected routes. No attempt was made to map the area completely, but a number of routes were surveyed across it, which permitted outlining the general features of the whole region with a considerable degree of accuracy, and where possible the geology of the areas between the lines of survey was inferred. The narrowness of the batholith in this district made feasible the mapping of both the eastern and western contacts over a considerable distance.

Topography

There are three physiographic provinces in Yukon that are continuous with similar divisions in adjacent parts of northern British Columbia and Alaska. These are the Coastal system, the Interior or Yukon plateau, and the Mackenzie Mountain system. Of these only the first two need be considered here in connexion with Aishihik Lake district.

From southern British Columbia to near the sixtieth parallel the Coastal system includes only the Coast range if the island range to the west be considered as part of the Coast range, but near the head of Lynn canal the simplicity of this province is interrupted, and from that point north and northwest the Coast range passes inland and becomes the innermost member of the Coastal system which, for this portion of its length, consists of a series of ranges and mountain masses separated by broad, deep valleys. From the head of Lynn canal, northwestward, the Coast range gradually becomes less prominent, and finally merges into Yukon plateau near lake Kluane.

The Coast range consists of an irregular complex of peaks and mountain masses that have a rough alignment along a northwesterly trending axis; the range is everywhere extremely rugged and precipitous, and consists of sharp, needle-like peaks separated by deeply cut valleys. In British Columbia the summits attain elevations of 8,000 to 9,000 feet above sea-level, but in Yukon they are much lower and stand at an average elevation of 5,000 to 6,000 feet above the sea.

The Interior, or Yukon, plateau stretches from northern British Columbia through Yukon and Alaska to Bering sea. It is in reality a broad geosyncline, which is higher at the margins than at the centre, sloping from both the east and west towards an axis which coincides very closely with the position of Yukon river and its tributary, Lewes river. The summits of the plateau back from the main waterways form a gently undulating plain which is broken only here and there by isolated mountain masses that rise above the general level. Into this upland surface the streams have cut broad valleys to varying depths. The upland surface in the vicinity of the main waterways is everywhere maturely dissected.

The descriptions just given of the Coast range and the Yukon plateau apply in a general way to Aishihik Lake district, which is situated along the margin of the Coast range, and thus includes parts of both provinces. The main difference lies in the fact that the Coast range in this section of the territory is lower, and consequently less rugged and precipitous than it is to the southeast. Some of the peaks have a tendency towards a sharp outline, and the valley walls, particularly along the smaller valleys, are steep, but numerous flat-topped forms which are more characteristic of the plateau province also occur. In fact, there is no marked division between the two provinces, and it is doubtful if the term Coast range should be applied to that part of the province north and west of Takhini and Dezadeash valleys. The only reason for applying the term is the continuation of the granitic batholith across the region. The hills to the south and west are much higher and more rugged than the Coast range in this part of its course, and finally culminate in the peaks of the St. Elias range, many of which may be seen from the district. To the northeast the hills are much lower, and this part of the plateau seems to have been naturally dissected.

The main valley of the district is Dezadeash valley, an east-west depression that stretches from Lewes river to the foot of St. Elias range, and is occupied in its eastern part by Mendenhall and Takhini rivers, flowing east; and in its western part by Dezadeash river, which drains into Alsek river. The divide between Mendenhall and Dezadeash rivers is only a few hundred feet in height, and is formed of sands and silts. It seems probable that this valley was once the site of a single river, draining, perhaps, to the west, and that the present drainage system is the result of glaciation.

The other main valleys of the area have a north to northwest trend. These include the valley occupied by the upper part of Mendenhall river and Hutshi lakes, and Nordenskiöld river, and in which the divide between the waters of the Mendenhall and the Nordenskiöld is only a few feet high; the valley occupied by Aishihik river and Aishihik lake, and by the west fork of Aishihik river and Sekulmun lake. There is also a northeasterly trending valley from the head of Mendenhall river to the Whitehorse-Dawson road. Most of these valleys afford good routes for travel.

General Geology

The rocks of the area include both igneous and metamorphic types. The igneous types include both volcanics and intrusives; the latter, the Coast Range intrusives, form one of the major features of the district. The volcanics occur only at a few scattered points, and are not as important as in areas to the north and south. The following table gives the list of formations.

Table of Formations

Recent and Pleistocene......	Superficial Deposits.........	Alluvium and glacial drift
	Dyke rocks	Quartz porphyry and related types
Jurassic..................	Coast Range Intrusives.....	Monzonites, granodiorites, granites, and related types
	Older Volcanics............	Andesites with associated tuffs and breccias
Precambrian (?)...........	Yukon group..............	Mica schist, quartz mica schist, chlorite schist, granite-gneiss, and crystalline limestone

Yukon Group

This name was applied by Cairnes* to include the metamorphosed rocks of both igneous and sedimentary origin along the Yukon-Alaska

*Cairnes, D. D.: "Yukon-Alaska International Boundary"; Geol. Surv., Canada, Mem. 67, pp. 40-44 (1914).

boundary north of Yukon river. The correlations he made at that time show clearly that he included in this group all the schistose and gneissoid rocks of Yukon basin, which had been determined by different workers to be the oldest in their respective districts, and which had been variously classed as pre-Devonian, pre-Silurian, or pre-Ordovician according to the age of the oldest overlying beds. Cairnes offered proof that the members of the Yukon group were in all probability Precambrian. As some of the correlations were made over considerable distances, and as degree of metamorphism is not by itself a reliable key to age, it is perhaps best to consider the Yukon group as a whole only tentatively as of Precambrian age, although the lack of definite evidence, in spite of the increased number of investigations among these rocks, that it is not Precambrian, tends to strengthen the original correlation.

The rocks of the Yukon group in Aishihik Lake district include both sedimentary and igneous types, and represent probably, different ages within the Precambrian, but they have been so highly metamorphosed that in many cases it is difficult to ascertain the nature of the original rocks, and consequently, to determine their history. The group is represented by mica schist, quartz-mica schist, chlorite schist, granite-gneiss, and crystalline limestone. This group forms, for the greater part of the area, the rocks into which the Coast Range batholith was intruded, and, therefore, the degree of metamorphism is high.

The mica schist is a greyish, medium-grained rock showing an abundance of mica, particularly on cleavage planes. Specimens examined under the microscope are seen to consist mainly of biotite and quartz, with minor amounts of chlorite and iron ore. Some specimens also contain calcite. The quartz grains are intergrown with a sutured texture, and the mica is usually arranged in leaves parallel to the planes of schistosity.

The quartz-mica schist is very similar in appearance and composition. Quartz is, however, the dominant mineral, with biotite or sericite subordinate. The quartz grains are nearly always intergrown, and have an arrangement along parallel lines with leaves of biotite or sericite arranged along the planes of schistosity. The rock has a decidedly quartzitic appearance, and is undoubtedly an altered sediment.

The chlorite schist is a greenish to greyish rock with a glistening appearance on a freshly broken surface. Individuals of biotite can be detected with the naked eye. Under the microscope the rock is seen to consist almost entirely of chlorite, biotite, and hornblende. A few small laths of feldspar, and minor amounts of iron ore also occur. The rock has a decided schistose appearance, and is most probably an altered igneous rock.

Granite-gneiss is one of the most abundant of the metamorphic rocks of Aishihik Lake district. It is most extensively developed along the western flank of the intrusives, but is also fairly common on the eastern margin. It is a greyish to pinkish rock, with a characteristic gneissoid texture, and in many cases with the development of phenocrysts, forming an augen gneiss. Under the microscope the essential constituents are seen to consist of quartz, orthoclase, plagioclase feldspar, biotite or hornblende, and micropegmatite. The quartz and feldspar show in some cases pronounced granulation; in most cases, however, the quartz grains are intergrown. The mica is usually arranged in parallel lines. In some specimens the rock is much more basic than those described above, and consists largely of plagioclase and augite, with minor amounts of secondary minerals, and exhibits less intense granulation. These variations were noted, however, at only one locality.

The crystalline limestone is abundantly developed along the trail leading up Mendenhall valley, and occurs plentifully in the region about the southern end of Aishihik lake; it is, moreover, in many cases associated in minor amounts with the other schistose rocks in other parts of the district. The limestone is white to brown and is more or less siliceous. The recrystallization is so complete that all trace of the original bedding has been destroyed. Lenses and veins of quartz, barren of sulphides, are common in the limestone; and in the vicinity of bodies of granitic rocks, garnet, epidote, and other silicate minerals are extremely abundant. In such cases careful search was made for sulphides, but without success. No fossils were obtained from the limestone in Aishihik Lake district.

Older Volcanics

The rocks included in this group have only a limited development in the district. The chief occurrence lies on the hills north and east of Hutshi lakes, and in all probability these rocks extend north on both sides of Nordenskiöld valley to join with areas of similar rocks shown on the Braeburn-Kynocks and Tantalus maps*. Other areas occur on the ridge between Hutshi lakes and Aishihik lake, and on the western side of Aishihik lake. Other small bodies were noted chiefly on the summits of the higher hills.

The andesites are green to red rocks, and exhibit, macroscopically, phenocrysts of feldspar. Under the microscope the feldspar is seen to be largely andesine, and the ferromagnesian mineral, hornblende or augite. Crystal tuffs containing fragments of crystals of these minerals in many cases accompany the andesites, as well as breccias with fragments of andesite and other rocks. There is little definite evidence to be obtained as to the age of these rocks in Aishihik Lake district, on account of the lack of sedimentary strata which would serve as time-markers. They are cut by the granitic intrusives wherever the two are found in contact, and are younger than the members of the Yukon group. In Whitehorse district to the southeast, some of the members of the Older Volcanics cut sediments of Lower Jurassic age, and are in turn cut by the granitic intrusives, which, from the evidence collected in Yukon and British Columbia, may range from Jurassic to early Cretaceous time.

Granitic Intrusives

The granitic intrusives form one of the major geological formations of Aishihik Lake district, both in areal extent, and in importance as possible ore-bringers. The granitic intrusives southeast of the district have a north-northwesterly trend, but at the eastern edge of the district they turn abruptly in a more westerly direction, and continue across the district in this direction towards the northern end of lake Kluane. They form a fairly narrow band 8 to 10 miles wide across the area, and a tongue of these intrusives also extends from Sifton mountains in the southeast of the map-area towards Hutshi lakes, and apparently dies out in the hills northwest of these lakes.

The Coast Range intrusives include a considerable variety of rock

*Cairnes, D. D.: Geol. Surv., Canada, Maps 10A and 11A, 1910.

types, but they have in general a granitic habit. The typical rock is coarse grained, greyish, and composed of quartz, feldspar, and mica or hornblende. Pinkish varieties also occur, as well as types that have a porphyritic habit, exhibiting crystals of feldspar 1 inch to 2 inches long in a mass of finer-grained material. Types rich in ferromagnesian minerals, and consequently darker in colour, also occur.

The typical rock of the Coast Range intrusives is medium to coarse grained, with the essential constituents visible to the naked eye. Under the microscope the main minerals present are seen to be quartz, orthoclase, plagioclase feldspar of intermediate composition, and biotite or hornblende or both. The quartz in most cases forms less than 20 per cent of the rock and the ratio of alkali feldspar to lime-soda feldspar is usually 5:3 to 3:5. The rocks, therefore, fall into the class of monzonites and granodiorites. In some cases the percentage of quartz increases to nearly forty, and the lime-soda feldspar becomes distinctly subordinate, placing the rocks definitely in the granite family. This variety is, however, less important areally than the monzonite or granodiorite type.

An attempt was made to determine whether there was a progressive change in composition across the batholith or along its strike, but the conclusion was reached that the variation from the normal type around any single locality was greater than the variation exhibited by the normal types either across the batholith or along its strike. No regular change in the normal type of intrusive was detected, but it must be remembered that the batholith at this point is narrow, and possibly no striking change is to be expected.

The main body of the batholith in Aishihik Lake district, as already noted, is in the form of a dyke-like body, 8 to 10 miles wide, with a tongue of granitic rocks occurring 6 miles to the north. The contacts of the batholith with the intruded rocks are rarely exposed, owing to the mantle of superficial deposits, which occupies the valley bottoms and much of the hill-sides and upland surface. Where observations could be made on the eastern contact, it was found to dip steeply, the angles observed being 55 to 70 degrees. The presumption is that the western contact had also a considerable dip. The general form of the batholith in this district, cutting as it does in a fairly narrow band across the country, regardless of the topography, supports the view that the contacts, in the vicinity of the surface at least, are steep. This view must perhaps be modified by the fact that the type of survey conducted permitted only of obtaining a limited number of points along the contacts, chiefly adjacent to routes of travel, with the remainder of the contact interpolated between these points. Taken as a whole the contacts, where observed, are highly irregular. The western contact is, unfortunately, concealed for the greater part of its length within the district by the valley deposits of the West Fork of Aishihik river. Along the eastern contact, where exposures could be found, the contact was found to be highly irregular, and the shattering effects of the intrusive upon the wall-rock were well illustrated. To the north of Moraine lake, blocks and fragments of the schistose rocks are included in the granites. The blocks vary from a few inches up to many yards in diameter, and in many instances the smaller blocks have rounded and indefinite outlines pointing to partial absorption by the intrusive. Tongues and stringers of granitic material pierce the inclusions, but *lit-par-lit* injection was not noticed, either in the case of the inclusions or in the wall-rocks of the batholith.

For the greater part of its length in Aishihik Lake district the batholith is in contact with the schistose rocks of the Yukon group, and it cannot be determined what part of the metamorphism of these rocks is due to the intrusion of the batholith, and what part is due to other causes. Along many of the contacts garnet is found in the schists, pointing to a certain degree of contact metamorphism. Where the limestones of the schistose group are in contact with the granites the degree of contact metamorphism is high; garnet, epidote, and other silicate minerals are abundant and in some cases make up the bulk of the intruded rock, but the zone where these minerals are found is quite narrow; in no instance were silicate minerals noted more than a quarter of a mile from the granitic contacts.

Pegmatite dykes may be included among the contact phenomena of a granite batholith. No true pegmatite dykes were noted along the eastern margin of the Coast Range batholith, nor have any such dykes been reported elsewhere along the eastern margin of the batholith in Yukon. The western contact of the batholith has not received much study in Yukon, but in the short stretch of the western contact exposed in Aishihik Lake district, pegmatite dykes containing large crystals of tourmaline are fairly abundant.

A study of the batholith and adjacent rocks along its eastern margin, from Atlin district in northern British Columbia northwest to Aishihik Lake district, reveals some important facts that have a bearing not only on the geological structure but also on the types of ore deposits that may be expected. The presence, on the tops of many of the higher hills, of bodies of the intruded rocks, leads to the belief that these are possibly remnants of the roof of the batholith. In Wheaton district, where work of a detailed character has been done*, several long, relatively narrow curtains of pre-Jurassic rocks occur in the batholith, are cut by the valleys to depths of 3,000 feet or more, and at the level of the valley bottoms are almost as wide as at their highest points. In the same district, small, irregularly-shaped patches of the older rocks outcrop at widely different elevations. These cannot be parts of the roof of the batholith but are inclusions. The method of batholithic invasion which best answers the known facts appears to be that of overhead stoping—the batholith advancing by the breaking away from the roof of fragments or blocks which sank in the magma that rose to replace them. The batholith also appears, in general, to have intruded the overlying rocks in the form of great tongues and dykes, from which branched off smaller portions. However, there is not the minute interfingering of the batholith and the older rocks that occurs in connexion with the Precambrian batholiths. There is little in the way of addition of granitic material to the intruded rocks, except in the form of distinct bodies such as dykes and sills. That a certain amount of marginal assimilation occurred seems evident, for at the contacts of some of the darker rocks the granite becomes darker as the contact is approached, but this is operative for a few feet only.

It is almost certain that a cover was maintained over the magma until it cooled. Further, it would appear that the roof of the batholith was highly irregular. This is, perhaps, best illustrated on the hills north of Champagne, where the summits are granite and, therefore, not at the roof of the batho-

*Cairnes, D. D.: "Wheaton District"; Geol. Surv., Canada, Mem. 31, pp. 74-76 (1912).

lith; passing northward, the schist contact appears at a distance of about 2 miles and at an elevation of at least 2,000 feet lower; still farther northward, schists are exposed in the bottom of Mendenhall valley; and on the higher hills to the north of this valley granite once more appears. If it be assumed that these granite bodies are connected beneath the schist cover, the original roof of the batholith must, indeed, have been highly irregular. Moreover, a study of the areal geology from Atlin to Whitehorse shows that there are numerous outlying bodies of granodiorite that are identical in appearance and composition with the intrusives of the batholith itself, and no evidence has as yet been presented to show that these are of a different age. They can, perhaps, best be regarded as peaks of the granitic body, which have, as yet, been barely deroofed.

Association of Mineral Deposits with the Coast Range Batholith

The mineral deposits located along this part of the eastern contact of the batholith also give some indication of the shape of the body. The following table is a summary of the types of ore deposits that occur along the eastern margin of the batholith from Atlin district northwest to Aishihik Lake district, and includes only those whose genetic connexion with the granitic intrusives may be assumed or has been expressly stated by the authors concerned*. All deposits, however, that are connected with outlying bodies of granites have been included.

Deposit	District	Country rock	Type
Gold-silver	Atlin	Slate, schist, andesite, and Coast Range intrusives	Hydrothermal
Gold-tellurium	Atlin	Slate	Hydrothermal
Silver-lead	Atlin	Granite and associated dykes	Hydrothermal
Antimony-silver	Atlin	Shale and argillite	Hydrothermal
Gold-copper	Atlin	Granite	Hydrothermal (?)
Copper	Atlin	Schist	Contact metamorphic
Gold-silver-lead	Windy Arm	Andesite	Hydrothermal
Gold-silver	Wheaton	Slate, schist, andesite, and granite	Hydrothermal
Silver-lead	Wheaton	Argillite	Hydrothermal
Antimony-silver	Wheaton	Andesite	Hydrothermal
Copper	Wheaton	Schist	Contact metamorphic
Copper	Whitehorse	Limestone and granite	Contact metamorphic
Copper	Giltana lake	Schist	Contact metamorphic
Copper	Nordenskiöld river	Andesite	Contact metamorphic (?)

It will be readily seen from this table that there are two types of mineralization, namely, contact metamorphic and hydrothermal. Contact

*Cairnes, D. D.: "Atlin Mining District"; Geol. Surv., Canada, Mem. 37, pp. 72-121 (1913).
"Windy Arm District"; Geol. Surv., Canada, Sum. Rept. 1916, pp. 34-44.
"Wheaton District"; Geol. Surv., Canada, Mem. 31, pp. 85-145 (1912).
"Lewes-Nordenskiöld River Coal District"; Geol. Surv., Canada, Mem. 5 (1910). Appendices I and II.
McConnell, R. G.: "Whitehorse Copper Belt"; Geol. Surv., Canada, 1907.

metamorphic deposits are believed to have been formed under conditions of high temperature and pressure, and consequently soon after the intrusion of the batholith. The hydrothermal deposits in this region, from a study of their mineral associations, belong mostly to deposits of the upper vein zone, that is, deposits formed under conditions of moderate temperature and pressure. As these occur not only in the surrounding rocks, but in the granodiorite also, it follows that they were formed at a later date than the contact metamorphic deposits, after the upper part of the granodiorite intrusion had solidified and cooled.

Moreover, as the mineral deposits of this region occur in a belt following the eastern margin of the batholith, and as the deposits have been found to be genetically connected with the batholith, it follows that the rocks to the east of the main boundary are really the roof of the batholith. This is further borne out by the facts that numerous outlying bodies of granodiorite occur to the east of the main margin of the intrusives and no evidence has yet been found in this region that these outlying bodies differ in age from the main body of intrusives. It follows that on the whole the eastern margin of the batholith in this region slopes gently eastward with recurrent upward projections whose summits have been laid bare to the east of the main margin. This conclusion does not agree with that of Schofield*, namely, a steeply-dipping and smooth-flowing eastern contact, with a narrow contact metamorphic zone.

The deposits of the contact metamorphic type occur for the most part at considerable distances from the main margin of the batholith and are found at the borders of outlying bodies of granodiorite. Deposits of this type, with one possible exception, are confined either to limestone, schist, or to the granodiorite. At one locality, Beeker creek**, a deposit of this type occurs in a schist inclusion, and deposits of hydrothermal origin occur in the granodiorite at approximately the same elevation. As the hydrothermal deposits are low temperature types, compared with the contact metamorphic, and as the differences in this case cannot be explained by zoning as ordinarily understood, it, therefore, appears that the time at which the deposits were formed becomes the deciding factor; that deposits formed soon after the intrusion of the batholith were of the contact metamorphic type; and that near them may be found deposits of the upper vein zone formed in the dying stages of volcanism from the same intrusion.

Dyke Rocks

The common dyke rocks of the district are, in general, merely phases of either the Older Volcanics or of the Coast Range intrusives, that is, either dykes of andesites or of granite porphyry, which are apparently closely connected with their respective periods of volcanism. There are, however, a number of dykes, chiefly in the northern end of the region, which, from their lithological characters, seem to correspond closely with more recent rocks found in other parts of Yukon. They are, for the most part, quartz porphyries and related types and are readily distinguished in the field, for they have always a white to yellow groundmass holding occasional crystals of quartz, feldspar, or mica. The quartz crystals are in

*Schofield, S. J.: "Salmon River District", Schofield and Hanson: Geol. Surv., Canada, Mem. 132, pp. 64-66 (1922).

**Cairnes, D. D.: "Wheaton District"; Geol. Surv., Canada, Mem. 31, pp. 110-111, 140-145 (1912).

many cases of the smoky variety. These rocks break readily into thin, irregular plates with a roughly conchoidal fracture, and give a ringing sound when struck with the hammer. They are, presumably, late Tertiary or early Pleistocene, for where definite evidence as to their age has been obtained in this and other districts, they are found to be the most recent of all the consolidated rock formations.

Superficial Deposits

The superficial deposits represented on the map are the thick accumulations in the valleys. The thinner deposits on the hill-sides and upland are not shown as a rule. The superficial deposits include, in addition to glacial drift, gravel, sand, clay, silt, soil, rock talus, and volcanic ash. These cover the valley floors to unknown depths and also spread over considerable parts of the hill-sides and upland. One of the most notable features of these deposits is the considerable thicknesses of fine, white silts. These are most conspicuous at the northern end of Hutshi lakes, as terraces along the west fork of Aishihik river, and along parts of Dezadeash river. Another notable feature is the occurrence of benches of gravel on the ridge between Hutshi lakes and Aishihik lake, and on the ridge between Aishihik lake and Sekulmun lake. The benches occur at all elevations up to the top of the lower saddles of these ridges. The streams entering the lakes have cut deep canyons in them and show that in places the gravels are at least 100 feet thick. The streams draining the lakes have, also, cut through the superficial deposits of their former valley bottoms, leaving terraces that increase in elevation above the present stream bed downstream. As these valleys were occupied by glaciers it is probable that the gravel deposits were formed along the margins of the valley glaciers either by streams draining toward the valleys or by streams draining along the edges of the ice. The retreat of the ice was toward the south and as the main divide between the waters draining to the Yukon and to the Pacific ocean by way of Alsek river lies to the north, lakes were formed between the retreating ice and the divide.

A number of terminal moraines were noted. One of these occurs in the valley between Sekulmun and Aishihik lakes, a second at the head of Cracker creek, and a third in the valley that stretches from the head of Mendenhall river to the Dawson wagon road. Other smaller moraines are common. In some instances the moraines have been flooded, giving rise to lakes of extremely irregular shape.

Mineral Deposits

No mineral deposits are being worked in Aishihik Lake district. Deposits of copper are known to occur in the vicinity of Giltana lake, and others have been reported from Nordenskiöld valley, a few miles northeast of the map-area, but on the whole the district may be classed as unprospected. This is perhaps not surprising, as the economic transportation of ore would be somewhat of a problem. The type of topography would facilitate the construction of roads should these be needed, but the long haulage to the head of navigation on Takhini river, the loading there, and the re-handling at Whitehorse and Skagway would entail such expense that only ore of very high grade could be profitably handled.

On the whole, Aishihik Lake district is considered a favourable field for the occurrence of mineral deposits. The importance of the granite batholith in connexion with ore deposits has already been pointed out. Some of the creeks crossing the western contact of the batholith, towards Kluane lake, have produced considerable amounts of placer gold, and there is no apparent reason why the creeks that cut the rocks adjacent to the western contact in Aishihik Lake district should not also carry placer gold. The chief difficulty lies in prospecting. The superficial deposits are, probably, very thick, and in many instances are not frozen, which renders prospecting by the methods ordinarily employed in Yukon out of the question. It is possible that points may be found towards the heads of these creeks where the superficial deposits are sufficiently thin to permit the prospector to reach bedrock, and thus test the ground.

The only lode deposits known in the area mapped occur at Giltana lake, and it is years since any work has been done on them. The claims were staked in 1907 and 1908 and were reported on by Cairnes*. The following summary of his account is included for the sake of completeness.

The deposits are located on both side of Giltana lake. On the northwest side the ore occurs at the contact between granite and limestone, and is in the form of narrow lenses of quartz and mineral. The widest lens observed was about 4 feet wide and, generally speaking, the lenses are only from 1 to 2 feet wide. They have no present economic value.

On the northeast side of the lake the rock formation is mica schist with limestone and quartzite. In places, the schist is mineralized with magnetite carrying copper minerals, chiefly chalcopyrite and malachite. The schist bands show almost all stages of mineralization from barren schist to nearly solid iron ore. The ore-zones average 6 to 10 feet wide, although one of 20 feet exhibiting intense mineralization was observed, and have been traced for distances of 50 to 200 feet, to where the mineralization becomes scanty or follows parallel bands. Three prominent ore bands were observed at different elevations on the face of the hill overlooking the lake. The deposits are genetically connected with intrusions of granite which occur in the vicinity. The best of the copper ore carries 1·35 per cent to 9 per cent copper and only a trace of gold.

A second copper deposit was reported by Cairnes from the hills overlooking Nordenskiöld valley north of Hutshi lakes**. In this case the ore occurs at the contact of andesite and limestone, and consists of magnetite impregnated with copper minerals, chiefly chalcopyrite, malachite, and azurite. The main mass is in the form of a hill of almost solid iron ore, about 200 feet wide and from 300 to 400 feet long. A second occurrence, where the richest ore is found, was exposed in a small open-cut where the ore was 10 to 12 feet wide, and was apparently not connected with the mass referred to above. A sample from the large mass showed no gold and 1·8 per cent copper; a sample from the open-cut yielded 0·025 ounce of gold to the ton, and 5·55 per cent copper.

Saline Deposits

Saline encrustations occur at many points along the valley of Dezadeash river and also along Aishihik river. This material is white and occurs

*Cairnes, D. D.: "Lewes and Nordenskiöld Rivers Coal District"; Geol. Surv., Canada, Mem. 5, Appendix II (1910).

**Cairnes, D. D.: Op. cit., Appendix I.

around the edges of lakes and small ponds, being left as a residue after the evaporation of the water. These saline encrustations also occur at many points as a thin deposit on top of the soil; in some of these cases there is apparently an abundance of stagnant water early in the spring, and the encrustations are left as the water evaporates. Samples of these encrustations, collected by D. D. Cairnes*, were examined in the laboratories of the Mines Branch, Ottawa, and proved to contain hydrated sulphates of lime and soda, with a small quantity of magnesium sulphate and insoluble argillaceous and organic matter. They are slightly ferruginous and contain small quantities of chlorides and phosphates. The potash content in six samples was shown to be from 0·2 to 0·3 per cent K_2O.

Conclusions

Mining has made practically no headway in Aishihik Lake district, but from the geology of the district there is no apparent reason why deposits of copper, silver, lead, or gold may not be present. Mineralization may extend a considerable distance east of the batholith. It is true that not all parts of the batholith are ore-bearing, and that on long stretches of the contact no mineral discoveries have been reported. The evidences of ore deposits cited above show that mineralization has taken place along the contacts in Aishihik Lake district, and, since this is the case, other ore deposits may be reasonably expected to be present.

*Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1916, pp. 33-34.

1927

Introductory Note

The following note with reference to field work in Yukon Territory in 1927 is included by G. A. Young, Chief Geologist, in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1928, page 14:

"W. E. Cockfield geologically and topographically explored an area of about 2,000 square miles in the vicinity of Dezadeash Lake, southwestern Yukon. A main reason for undertaking this work was to outline a part of the western border of the Coast Range batholith, a body with which many important mineral deposits are associated in Yukon and British Columbia. Cockfield also examined ore deposits at Fifteenmile Creek on Yukon River below Dawson; at Rude Creek; and at Whitehorse. A report upon Dezadeash Lake area, accompanied by a map and short reports upon the ore deposits of the three localities mentioned, appears in Summary Report, 1927, Part A."

DEZADEASH LAKE AREA

by W. E. Cockfield

During the summer of 1927, exploratory work was done in the region lying between Kusawa and Dezadeash lakes. The area lies between latitudes 60° and 60° 45′ and longitudes 136° 00′ and 137° 15′. The town of Champagne is a suitable base for the western part of the district. From Champagne the Dalton trail leads to Haines on the Alaskan coast, and crosses the western part of the area. This trail is still in fair condition for pack animals, although blocked to some extent by windfalls. All points on Dezadeash lake may also be reached from Champagne by ascending Dezadeash river, which is fairly deep, and, with the exception of a number of minor riffles, for the most part sluggish, so that it offers no serious obstacles to the use of poling boats, or boats equipped with small outboard motors. The lake, on the other hand, is usually very rough, and for long periods at a time cannot be crossed in safety by the ordinary light-draught river boats.

Kusawa lake (better known in the district as Arkell lake) may be reached from Whitehorse by descending Lewes river and ascending Takhini river. This route is easily navigable for steamers and shallow-draught boats of good power to a point about 4 miles above Mendenhall landing. At this point occurs a rapid, several chains long, with a considerable drop, and obstructed by numerous boulders. Small boats may be taken up and down by lining. From this rapid to the lake the river is continuously swift, with a number of very fast riffles or rapids. Boats with good power may ascend all except the swiftest water, where lining is necessary. On the whole there is sufficient water for navigation by small boats. A trail also leads from the Whitehorse-Kluane wagon road at Mendenhall landing, to the northern end of Kusawa lake, and pack animals may be taken south along the western shore of the lake for about half its length; beyond that point the shores are bordered by steep, rocky walls which render the use of pack animals impossible. A poorly defined trail leads from the central part of Kusawa lake by way of Frederick lake to the Dalton trail at Kluhini River crossing. This trail, although practicable for foot travel, is impassable for pack animals by reason of swamps and rock bluffs at the head of Frederick lake. Kusawa lake, like Dezadeash lake, is subject to violent windstorms. However, they are not so continuous, and with care, small boats may be used on the lake in comparative safety.

As no base map of sufficient accuracy existed, a survey was conducted in the district, to outline the major features of drainage and topography. No attempt was made to map the area as a whole. Narrow stretches along readily accessible routes of travel were mapped, so as to obtain, in a minimum time, as much information as possible regarding geology and topography of the district. The writer was ably assisted in this work by Messrs. N. T. Ellis, E. J. Lees, and E. A. Goranson. Mr. Ellis took charge of the party during the writer's absence on investigations of mineral properties lying outside the district.

Topography

The area is on the western flank of the Coast range and in consequence is for the most part rugged. Ragged and needle-like peaks, typical of the Coast range, are well developed. The mountains west of the Coast range, using this term as meaning the terrain underlain principally by the granitic rocks of the Coast Range batholith, are fully as high as the Coast range. One or more ranges occupy the region between the Coast range and St. Elias mountains. The mountains of this range or ranges attain altitudes of about 7,000 feet, and hold many glaciers. They appear to be formed largely of folded sedimentary rocks.

One of the main features of the district is the number of large lakes. Of these the largest are Kusawa, Dezadeash, and Frederick. Kusawa lake occupies a somewhat zigzag valley, having, however, a general north-south trend. The central part of the lake is in a transverse valley having a northwest-southeast trend, and continuing beyond the lake to the northwest to Shawak valley, being occupied in turn by Frederick lake, part of Dezadeash lake, part of Kathleen lake, and lake Kluane. From this valley to the north end of the lake, terraces or benches of gravel and sand are common on one side of the lake or the other. They are, however, most commonly to be found on the western side of the lake, the other side being occupied for the most part by a steep, rocky wall. At the foot of the lake, these terraces are cut through by Takhini river, which is evidently lowering its channel at this point relatively quickly. The water flowing from the lake is quite clear, but it quickly picks up a load of sediment, and is turbid before reaching Mendenhall landing, 11 miles below. This stretch of Takhini river flows in a north-south depression, but soon enters a wide east-west valley, having a much lower grade. The river on entering this valley flows east, and save for occasional riffles, the greater part of the stretch from Mendenhall landing to the mouth is comparatively slack water. The southern end of Kusawa lake lies in a steep-walled, U-shaped depression; at the northern end the valley is more open, and the hills lower.

Dezadeash lake occupies a broad valley bordered by low hills to the east, and south of Shawak valley by a high range to the west, to which the name Dezadeash mountains has been applied. The lake is drained by Dezadeash river which flows north through a broad valley for some miles, to where, by a narrow U-shaped valley at mount Bratnober, it enters a continuation of the depression followed by Takhini river, but turns west, and flows into Alsek river. The height of land between Yukon and Alsek drainage in this valley is very low, the divide between the waters of the two rivers being probably less than 300 feet high, and formed by sand hills. Dezadeash river between the lake and Champagne is bordered for the greater part of the distance by swampy flats, with numerous lakes representing cut-off meanders.

Shawak valley is a wide depression extending southeastward from lake Kluane to Dezadeash lake, from where a valley continues in the same line to Kusawa lake. As has been pointed out, Shawak valley contains parts of some of the larger lakes of southwestern Yukon, and the divide between the drainage of this valley and the drainage directly to the Alsek by way of Klukshu lake and Klukshu river, and Tatshenshini river, and also by way of Alder creek, Bates and Mush lakes, and Tatshenshini river, is very low. The view was put forward by Brooks* that this valley formerly carried the drainage from Upper White river to the sea by way of Tatshenshini and Alsek rivers. Although Cairnes** has shown that so far as White river is concerned this course is impossible, it nervertheless is evident that Shawak valley was, previous to the Glacial epoch, the line of one of the main drainage features of the district. That there have been changes in drainage is evidenced in part by the sudden lowering in grade of Takhini river on entering the east-west valley which carries it to the Lewes; the gradual steepening in grade of Dezadeash river on entering the same valley; the broad Shawak valley, occupied in part by large lakes, and in part by small streams; and the high gravel and silt benches along parts of Kusawa lake, Dezadeash lake, Takhini, Dezadeash, and Kluhini rivers. There are not, however, sufficient data at hand to permit of outlining the preglacial drainage.

General Geology

The rocks of Dezadeash Lake area include sedimentary, igneous, and metamorphic types, ranging in age from Precambrian to Tertiary. The oldest rocks are represented by a group of schists and gneisses, thought to belong to the Yukon group, which is considered Precambrian. Following these is a thick series of argillites, presumably Palæozoic, and some volcanics tentatively classed with the 'Older Volcanics' of about Jurassic age. The Coast Range Intrusives form an extensive terrain, and cut all the formations listed above. No new evidence was obtained in Dezadeash Lake area as to the age of the intrusives. The youngest consolidated rocks of the district are dykes and small masses of quartz porphyry and granite porphyry. Overlying the rock of most of the valley bottoms, and much of the side hills and uplands, is a mantle of superficial deposits, including sand and gravel, silt, boulder-clay, and talus.

Descriptions of Formations

Yukon Group

The rocks of this group are extensively developed in Dezadeash Lake area. They are all schistose or gneissoid, and include mica, hornblende, and chlorite schists, granite-gneiss, and crystalline limestone. The mica schists are grey, medium grained, and with a pronounced development of mica on the planes of schistosity. They consist of quartz and mica, with subordinate feldspar and chlorite. The proportion of quartz to mica varies

*Brooks, A. H.: U.S. Geol. Surv., 21st Ann. Rept., pt. 2, pp. 354-355 (1900).

**Cairnes, D. D.: "Upper White River District"; Geol. Surv., Canada, Mem. 50, pp. 60-62 (1915).

widely in different specimens; ranging from types in which mica is abundantly developed to others in which the mica is rather sparse, and which approach quartzites in composition. The quartz grains are usually intergrown. The mica is arranged in parallel bands that occasionally show intense plication even in a hand specimen, sweeping in a series of curves through the specimen.

The chlorite schists are bright green to grey rocks with pronounced foliation, and a glistening appearance on a freshly broken surface. They consist of varying amounts of chlorite, biotite, and hornblende, with laths of feldspar, and minor amounts of magnetite.

The hornblende schists are dark greenish rocks more massive in appearance than the chlorite schists, but still with pronounced foliation. They consist largely of hornblende and feldspar, with minor amounts of chlorite and magnetite.

The granite-gneiss is grey to pink, with characteristic gneissoid texture, and at many localities with an abundant development of crystals of feldspar forming an augen gneiss. It consists essentially of quartz, orthoclase, plagioclase feldspar, biotite or hornblende or both, and micropegmatite. The quartz and feldspar in some cases show granulation, but in most cases the quartz grains are intergrown, with a sutured texture. Mica when present is arranged in parallel bands. In some specimens the individual leaves of mica show bending or crushing against an individual of quartz or feldspar.

Crystalline limestone is not abundantly developed in Dezadeash Lake area, being most common on the hills east of Frederick creek, where it is associated with other members of the schist group. There is also a narrow band in the schists east of the foot of Sixmile lake. The limestone is white to brown, and more or less impure, being usually quite siliceous. Practically all traces of the original bedding have been destroyed.

On the basis of their lithological characters, and from the fact that they are the oldest rocks of the district, these rocks are tentatively classified with the Yukon group. The rocks of this group have been variously classed as pre-Ordovician, pre-Devonian, and so forth, according to the age of the oldest overlying strata in different districts, but Cairnes* has offered evidence to show that all developments of the Yukon group are, in all probability, Precambrian.

It is evident that they include sediments and igneous intrusions into those sediments, but it is almost impossible to unravel the original succession.

Palæozoic (?) Argillites

The argillites are dark, coarsely bedded rocks seldom strongly cleaved, but in some instances considerable mica has developed and they pass into schists. A number of greyish quartzitic bands occur, and also occasional conglomeratic phases. No limestone beds were noted in the series. A similar group occurs to the southeast in Rainy Hollow district, but contains metamorphosed limestone beds.

The argillites nearly everywhere are highly inclined, the angles of dip ranging from 50 to 85 degrees. The best section of these beds seen

*Cairnes, D. D.: "Yukon-Alaska International Boundary"; Geol. Surv., Canada, Mem. 67, pp. 40-44 (1914).

was along part of the western shore of Dezadeash lake and west up the valley of Alder creek. Here the beds are inclined uniformly at about 85 degrees, and unless it be assumed that there has been repetition by faulting or isoclinal folding, as seems likely, a tremendous thickness is represented. Evidences of faulting were noted along some of the tributaries to Alder creek near the granitic intrusion in that locality.

No fossils were found in this group. The rocks apparently overlie the Yukon schists, and are cut by the granitic intrusives. In the limestones and argillites of Rainy Hollow district no fossils were obtained, but McConnell reported that from a group apparently belonging to the same series south of the International Boundary, specimens of a Carboniferous fauna had been obtained. Tyrrell reported finding specimens of *Bythotrephis* from dark calcareous shales along Unahini river, 7 miles north of Dalton post. Some confusion exists as to this locality, as the name Unahini is applied to different streams on different maps. It is believed, however, that the locality referred to is the stream named Klukshu river on the writer's map, and consequently that the rocks from which the fossils were obtained are included in the series under discussion. The specimens were referred by Ami to the Lower Palæozoic. The evidence as to age is, therefore, somewhat contradictory, or else rocks ranging in age from Ordovician to Carboniferous are present.

"Older Volcanics"

These rocks have only a limited development in Dezadeash Lake area, occurring in a mass at the southern end of the area along the Yukon-British Columbia boundary line. At this point they have been highly altered by a nearby granite intrusion. Elsewhere they occur as dykes.

The rocks are green to black, with a texture ranging from aphanitic to porphyritic. Unaltered specimens consist mainly of hornblende or pyroxene, and plagioclase feldspar. Specimens from the area near the interprovincial boundary are almost entirely altered to serpentine and magnetite.

These rocks are cut by the granitic intrusives. Beyond this fact no other data as to their age were obtained. Because of their similarity to rocks that elsewhere in Yukon have been grouped as the 'Older Volcanics' they are provisionally placed in this group, which is probably of Jurassic age. The altered rocks in the vicinity of the boundary present somewhat of a problem. It is quite possible that they should be correlated with somewhat similar rocks in southern Yukon and northern British Columbia known as the 'Gold series' and probably of later Palæozoic age, but as this correlation is somewhat in doubt, the writer prefers for the present to class them with the porphyrites of Dezadeash district.

Coast Range Intrusives

The rocks of this group, considering their areal extent and their importance as possible ore bringers, constitute one of the major geological features of Dezadeash Lake area. The district includes the western edge of the Coast Range batholith, and consequently considerable areas are underlain by granitic rocks. In Kusawa Lake section, granitic rocks underlie practically the whole area except for a few curtains of schist. To the west, in Dezadeash valley, the main boundary of the batholith crosses the valley twice, and swings to the southeast towards the head of Tatshenshini river. West of this boundary, the rocks are chiefly schists and argillites.

The Coast Range granites are typically grey to pink, coarsely textured, and composed of quartz, feldspar, and mica, or hornblende, or both. The typical rock belongs to the class of monzonites and granodiorites, but more acid and more basic varieties occur, including dark types rich in ferromagnesian minerals and porphyritic types with large crystals of pink feldspar.

The western contact of the batholith is usually obscured by drift and float accumulations. At those points where the contact could actually be seen, the observed dip of the contact is steep, but the general irregular course of the contact and the widespread development of contact minerals, such as garnet in the schists, seem to indicate that the contact in general is gently sloping. The effects of metamorphism on the intruded rocks is a difficult problem, as the bordering rocks nearly everywhere are schist. It is not known what part of the metamorphism is due to the injection of the batholith, and what part is regional metamorphism. Garnet is abundant in the schists at some localities, particularly in the vicinity of the contacts, and its occurrence at these places is regarded as a phenomenon of contact metamorphism.

Pegmatite dykes occur, but are by no means common.

No new evidence with respect to the age of the batholith was obtained. The granitic rocks cut all the consolidated rock formations except a few dykes and small masses of granite porphyry and quartz porphyry. The evidence obtained to date in Yukon indicates that the granite is more recent than the lower part of the middle Jurassic and older than certain Tertiary rocks. Beyond this the age is not as yet fixed.

Quartz Porphyry and Granite Porphyry

These rocks are the youngest consolidated rocks of the district. They occur chiefly as dykes and small masses.

Typically they are light coloured, weathering either red or yellow, so that they are conspicuous for long distances and may lead the prospector to believe that they are the weathered outcrops of veins. The coloration, however, is due to the oxidation of pyrite which nearly everywhere is a primary constituent of the rocks. Almost all these rocks are porphyritic, although fine-grained or aphanitic varieties occur. They have in most case a white to yellow groundmass in which lie occasional crystals of quartz, feldspar, or mica.

These rocks cut the granitic intrusives. In other parts of the Yukon, they are referred to the late Tertiary or early Pleistocene.

Overlying all the consolidated rock formations is a mantle of superficial deposits. This covers most of the floors of the valleys, and also much of the valley walls and upland surface. It consists chiefly of sand and gravel, silt, boulder-clay, talus, and rock rubble.

Economic Geology

No mineral deposits are being worked within the region mapped. This is not surprising since little or no prospecting has been done, and such as has been done has mostly been a search for placer gold. The district lies along the western edge of the Coast Range batholith, and for that reason, should be considered as favourable ground for the prospector. It is not far removed from Rainy Hollow district where copper-gold deposits are known, and Rainy Hollow district is also situated on the western margin of the Coast Range batholith. In addition to the Rainy Hollow deposits, bodies of galena and chalcopyrite are reported to occur some 30 miles south of the interprovincial boundary. Specimens of ore from these bodies were shown to the writer by the Indians at Dalton post, but time did not permit of making an examination of the locality.

The only deposit which, to the writer's knowledge, has been worked in the area, is a deposit of placer gold on Shorty creek, flowing into the head of Dezadeash lake. According to reports, an attempt was made to work this some years ago, and a minor amount of gold was obtained; but the attempted operations were on a large scale, and the result was a financial catastrophe.

Towards the close of the field season, some excitement was caused by Indians reporting placer gold on Squaw creek. Very little information was available, and the lateness of the season precluded making a visit to the locality. Squaw creek enters Tatshenshini river about 4 miles below Dalton post. This creek, according to report, rises in British Columbia. Staking took place on both sides of the boundary line; practically all the staking was done by Indians. The creek is reported to rise from a glacier, to have a steep gradient, and a large number of big boulders in its bed. The discovery was made at a bend in the stream, where the depth to bedrock is reported to be 6 to 8 feet. A small amount of gold, 11 ounces 12 pennyweights, was brought to Whitehorse from the Discovery claim. The gold is prevailingly coarse with a rough surface, and, quite evidently, comes from close to its point of origin. The gold is coated black.

Coal has also been reported to occur on Squaw creek.

SILVER-LEAD DEPOSITS OF FIFTEENMILE CREEK

by W. E. Cockfield

Considerable interest was aroused in Yukon by the staking during the winter of 1926 of a number of claims on Yukon river in the vicinity of Fifteenmile creek, 25 miles below Dawson. High values in silver and lead were obtained from some float found on the river bank, and as the occurrence is favourably situated with regard to transportation, the writer was instructed to visit it.

There are three distinct locations: the upper is about a mile below the mouth of Fifteenmile creek; the middle about 6 miles below the upper, opposite the mouth of Roal creek; and the lower about 5 or 6 miles farther down the river, opposite the mouth of Cassiar creek. The upper locations, in the vicinity of Fifteenmile creek, are re-locations of claims staked a number of years previous, but allowed to lapse.

General Geology

The geological conditions at all three localities are similar. The greater part of the bedrock of the district is schist, in large part quartz-mica schists of the Nasina series*, but including also mashed diabases similar to the Moosehide diabase**. The schists include numerous bands of limestone and dolomite. These bands are usually discontinuous, and can be traced only for short distances along their strike. The schists are highly disturbed and evidence of faulting is marked. Intrusive into the schists are dykes of porphyrite.

Mineral Deposits

The ore deposits are with one exception confined to the bands of limestone or dolomite. The ore minerals, chiefly galena and zinc blende, but with some chalcopyrite and its oxidation products, azurite and malachite, occur as disseminations in the calcareous bands, or in small quartz stringers cutting these bands. The mineralization is scanty, and although high assays may be obtained from picked samples, it is believed that samples taken over reasonable mining widths would show low values.

Very little recent development work has been done. In most cases only short open-cuts have been driven. On the Camp Bird claim, float on the beach of the river has been traced up the slope to the deposit in place. From the talus, which has undergone a rough concentration by nature, a shipment of 5 tons of hand-sorted ore was made.

Cassiar Creek

A deposit occurs about 2 miles above the mouth of Cassiar creek, on the right, or eastern bank of Yukon river. The outcrop is below mean water-level of the river, and only visible at certain seasons of the year. At this point lenses of limestone are extremely abundant in the schists, and one of these lenses carries galena and zinc blende in streaks and small masses. The streaks of galena apparently are short, and in most places the limestone is barren. The widest streak noted by those working the property measured about 8 inches and consisted of galena disseminated in limestone. An open-cut has been run along the strike of the limestone, and encountered three of these streaks, but they apparently pinched out in a few feet, for the writer could find no mineral in the walls and floor of the open-cut. A grab sample was taken of the material that had been removed from the cut. This included, however, only material that showed some galena. This was assayed and yielded 4·5 ounces of silver to the ton and 10·04 per cent lead.

Roal Creek

The occurrences at this locality are on the eastern bank of Yukon river, opposite the mouth of Roal creek. There are in all twelve claims, and they are the property of Louis Roal, P. Rost, and E. Chapman. At the upper workings, the country rock consists of schist cut by a porphyrite dyke. The schist contains beds and bands of limestone. A limy bed in the schist is partly replaced by disseminated galena and zinc blende. This bed is about 8 inches thick. The mineralization is rather scanty.

At the lower workings the country rock is schist with serpentine rock (Moosehide diabase) and a bed or replacement of dolomite. The dolomite in places carries considerable mariposite and is there a bright green. A short tunnel has been driven into the schist at this point, but does not

*McConnell, R. G.: "Report on the Klondike Gold Fields"; Geol. Surv., Canada, Ann. Rept., vol. XIV, pt. B, pp. 12-15 (1905).

**Idem., pp. 22-23.

penetrate to the dolomite-mariposite bed. There are no minerals of economic value visible at this point.

Fifteenmile Creek

At the upper discovery, namely near Fifteenmile creek, upwards of sixty claims have been staked, but by far the greater number have no mineral showings, and little has been done on them in the way of assessment work. The three principal claims lie along the beach of Yukon river, at the bend below the mouth of Fifteenmile creek. These are the Camp Bird, Yukon Chief, and Yukon Maid, owned and worked by P. Rost. From the Camp Bird, a shipment has been made of five tons of material that occurred as float on the beach.

The chief showing on the Camp Bird is somewhat similar to occurrences already described. Lenses of dolomite occur in the schist. These lenses have been highly faulted, and are difficult to follow for any distance. The dolomite contains seams of galena and zinc blende, with subordinate chalcopyrite, malachite, and azurite. These seams range in thickness from less than 1 inch up to about 8 inches, but, as a whole, the mineralization is scanty. Picked samples of the float on the beach have yielded high assay values, ranging from 200 to 500 ounces of silver to the ton, but it is doubtful if the deposits would average more than a few ounces over a reasonable mining width.

On the Christal claim, lying east of the Camp Bird, and 700 feet in elevation above the river, the deposit varies from the type. The mineralization is confined to stringers of quartz that cut the schists. The stringers range from an inch to two in thickness up to 8 inches, and are sparsely mineralized with specks of galena and chalcopyrite.

Genesis

There is, in the district, no known intrusive mass of sufficient size to cause the widespread mineralization in the schist. Disseminations of sulphides are common in many areas of crystalline schists and in certain cases their present manner of distribution may be attributed to regional metamorphism regardless of how the sulphides were originally introduced. Many such disseminations occur in the schists of Yukon, but in all known cases, the processes of concentration have not proceeded far enough to form workable ore deposits.

These deposits along the Yukon also have meagre mineralization, so that it is doubtful if mining could be made to pay.

SILVER-LEAD DEPOSITS OF RUDE CREEK

by W. E. Cockfield

Attention was first attracted to Rude creek as a placer gold camp in 1915, and the creek was worked to some extent in the spring and summer of 1916, but on most of the claims gold was not found in paying quantities, and after a short time most of the claims were abandoned. At that time an outcrop of galena was known on the creek, but it attracted little attention and was not staked until some years later.

Rude creek is about 5 miles long, has a steep gradient, and is a tributary of Dip creek, which in turn flows into Klotassin river. Rude creek lies some 15 miles west of Yukon river, and is reached by means of a trail from Isaac Creek landing, the distance by this trail to the workings being about 18 miles. The trail is mostly in rather poor condition for anything except travel afoot, and large stretches would require rebuilding before supplies could be hauled in or ore hauled out.

General Geology

The district was examined in 1916 by Cairnes* and the general geology may be summarized from his report as follows.

The oldest rocks of the district are schistose or gneissoid, and belong to the Yukon group, thought to be Precambrian. They consist of mica schists and gneisses, quartz-mica schists and gneisses, schistose and gneissoid quartzites, phyllites, and bands of crystalline limestone.

More recent than the members of the Yukon group are some andesitic volcanics, thought to be contemporaneous with the 'Older Volcanics' of Upper White River district. These have a limited development and are mainly andesites, basalts, and related types.

The most extensively developed rocks are granitic rocks, which form a batholith that was explored for a length of 50 miles without reaching either end, and has a width of from 15 to 20 miles. The rocks of this batholith range from granite to diorite, with accompanying porphyritic phases. Their age was not determined. They present, however, such striking similarities to the Coast Range Intrusives, that it was thought that they may be an outlying or subjacent part of the Coast Range batholith.

More recent than the granitic intrusives is a group of rocks corresponding to the 'Newer Volcanics' of Upper White River district. These are mainly andesites and basalts.

The most recent rocks are dykes of rhyolite, granite porphyry, and related volcanics.

Trombley Creek, a branch of Rude creek, on which the silver-lead property occurs, lies wholly within the granite. The closest point at which rocks of the Yukon group occur is near the mouth of Rude creek.

Claims

About twenty-five claims and fractions have been staked around the discovery. A group of eight claims, including the Discovery, has been optioned to C. U. Stuart of Boston, Mass., for a period of three years from March 30, 1927. The greater number of the outlying claims are also under option to Mr. Stuart.

Three cabins are on the claims and are sufficient to provide accommodation for a small crew.

Ore Deposit

The ore-body consists of a replacement of granite by galena and other minerals along a small fissure in the granite. This fissure is somewhat irregular in its trend. The granite bordering the fissure is leached to varying distances, and minerals have been deposited in it to varying distances from the fissure, but in no observed case at a greater distance

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*Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept., 1916, pp. 20-33.

than 40 inches. Movement along the fissure apparently has been relatively slight, and the fissure has the appearance of a short and somewhat irregular contraction crack, formed at the time of cooling of the granitic mass.

The mineralization consists mainly of galena and zinc blende, with pyrite and carbonates of lead and iron. A small amount of black stain believed to be manganese oxide, and derived possibly from manganiferous siderite, coats much of the granite adjacent to the fissure. A section across the 'vein' at its widest part is as follows:

	Inches
Galena, with some carbonates	4 to $4\frac{1}{2}$
Leached granite with disseminated galena and streaks of galena	6
Leached granite with manganese (?) stain and some carbonates	30

The writer took three samples from the open pit: No. 1 being of the 4 inches next to the hanging-wall; No. 2 of the next 6 inches, showing some galena mineralization; and No. 3 of the remaining 30 inches of the vein. These were assayed with the following results:

Sample No.	Gold, ozs. per ton	Silver, ozs. per ton	Lead, per cent
1	0·01	122·46	37·16
2	none	73·78	15·55
3	none	2·43	0·79

It is apparent that there is a streak of good ore 4 inches wide, a streak of fair ore 6 inches wide, and that the balance of the 'vein' is practically barren.

The 'vein' outcrops at the level of the creek bed, and the stream has been diverted by a bedrock drain. A pit has been sunk 8 feet on the deposit. On the west side of the pit, an adit 72 feet long has been driven westerly, with, at 49 feet, a crosscut to the south approximately 18 feet long. The deposit does not show in this underground work for more than a few feet beyond the portal. No fault was observed that would tend to throw the deposit to one side or the other of the adit. The only part of the vein found in the workings was concealed in the floor at the time of the writer's visit, but from descriptions it is evident that the vein pinched out within one set from the portal of the adit. The underground work has, therefore, been entirely wasted.

In the other direction, i.e., eastward from the portal of the adit, there is the lens 40 inches wide with a well-defined hanging-wall, and indefinite foot-wall, but this body pinches out on the floor of the pit towards the rock drain. The showing thus consists of a mineralized lens 12 to 14 feet long, with a maximum width of 40 inches, and a dip of 45 degrees to the south. As such lenses have in general a depth somewhat in relation to their length, it is safe to assume that the amount of ore in the lens does not exceed 5 tons, with an average content of 93 ounces of silver, and 24 per cent lead. This estimate excludes the greater part of the width of the lens because sampling revealed practically no values thereon.

There is not sufficient ore in sight or promise of sufficient ore to justify serious consideration of this property as a producer. Such deposits, however, are sometimes of importance in indicating the presence nearby of other, larger bodies. The writer, therefore, carefully examined the float in the creek, the old placer dumps, and the placer concentrates of the only placer claim working on the creek. A small amount of galena float has been found at various times on the creek, and also in the placer workings, but the quantity is not sufficient to justify the hope that large deposits of galena border Rude creek. In a region such as Rude creek, which has not been glaciated, galena float should be of common occurrence if large deposits of this mineral occurred in the vicinity, but this was not found to be the case. The writer was, therefore, forced to conclude that the chances were decidedly against the finding of large deposits of galena on Rude creek.

PUEBLO, TAMARACK-CARLISLE, AND WAR EAGLE-LEROI PROPERTIES, WHITEHORSE COPPER BELT

by W. E. Cockfield

Richmond Yukon Company, Limited, was engaged in 1927 in prospecting the Pueblo, Tamarack-Carlisle, and War Eagle-LeRoi groups in the Whitehorse copper belt. These groups are from 4 to 6 miles by road from Whitehorse. The Pueblo and Tamarack-Carlisle are owned by Richmond Yukon Company, and the War Eagle-LeRoi is under option, the price to be paid as a royalty on production.

Claims were staked in the Whitehorse Copper belt during the time of the Klondike gold rush in 1898 and 1899, and were prospected during the next few years. Some of the properties were operated at different times up to about the year 1920 or 1921. In most cases where continuous mining was attempted, the operations resulted in a heavy financial loss due to chiefly, perhaps, two causes: first, the deposits are of the type known as contact metamorphic, a type in which lenses and irregular bunches are common, but in which, frequently, the individual ore-bodies are entirely independent of one another, thus entailing the expenditure of large sums in the search for ore-bodies, particularly where this is done by means of underground workings such as drifts and crosscuts; and, second, few of the mines ever had in sight at one time sufficiently large ore-bodies to justify the erection of a concentrating plant; crude ore, therefore, had to be shipped at freight rates not greatly differing from what concentrates would have borne.

The chief shippers of the camp to date have been the Pueblo, Copper King, Grafter, and Valerie.

The Pueblo was the largest producer and shipped in the neighbourhood of 140,000 tons of ore. Following a cave-in, the mine was shut down, but was subsequently reopened, and in the opinion of the management at that time, all the ore that was extractable was removed. The Pueblo venture resulted in a heavy financial loss, which was, to a large extent, due to the cost of pumping and timbering. The mine was wet, making from 500 to 600 gallons of water a minute, and some of the ground was soft and difficult to hold. Pumping was done by steam power, using wood as fuel, and the power cost was consequently high.

The War Eagle and Carlisle groups were operated only in a small way, and the shipments from them did not exceed a few thousand tons.

General Geology

In 1906 the district was examined by McConnell* whose report is still the authoritative work on the district. The following brief summary from this report gives the essential facts with regard to the geology and ore deposits.

The rock formations, in order of age, consist of limestone, porphyrite, granite, and granodiorite, porphyrite dykes, and basalt. Of these only the limestone and the granitic rocks are economically important. The principal ore-bodies occur in the limestone close to or adjoining the granitic contacts, but discoveries have also been made in the granitic rocks at considerable distances from the limestone. Copper minerals have also been found in the porphyrites, but such occurrences have not proved of economic value.

Ore Deposits

The principal copper minerals are bornite and chalcopyrite. Tetrahedrite and chalcocite occur, and minerals resulting from the oxidation of the sulphides, such as the carbonates, malachite and azurite, the silicate, chrysocolla, and the oxides, cuprite and malaconite, are prominent but are seldom important as ores except at the Pueblo. Cuprite is occasionally associated with grains of native copper.

The iron sulphides, pyrite and pyrrhotite, are not abundant. The iron oxides, magnetite and hematite, occur in large masses. Magnetite is rarely absent from the mineralized areas, and occurs in lenses from a few inches up to 360 feet in length. Hematite is less common, but is the principal mineral in the Pueblo lode.

Other metallic minerals of lesser importance are: arsenopyrite, stibnite, sphalerite, and molybdenite. Gold and silver occur in small quantities and both are occasionally found native.

The principal non-metallic minerals are garnet, augite, tremolite**, actinolite, epidote, calcite, clinochlore, serpentine, and quartz. Of these, garnet, augite, epidote, calcite, and tremolite (wollastonite?) are the most abundant.

The ore-bodies fall into two classes: those in which the copper minerals are associated with magnetite and hematite; and those in which the gangue consists chiefly of the silicate minerals.

The Whitehorse deposits possess all the characteristics of contact metamorphic deposits and are unhesitatingly referred to that class. The location of the ore-bodies, and their constituent minerals leave little doubt as to the correct classification of the ore deposits. Bodies of this type are apt to be irregular and bunchy, a condition which has been borne out by many of the Whitehorse deposits and which undoubtedly adds considerably to the cost of mining.

The work of Richmond Yukon Company to date has been largely of the nature of prospecting with the diamond drill, the aim of the company, apparently, being before planning any elaborate scheme of development work to establish whether or not there is sufficient ore on its properties to justify the erection of a concentrator. The field work latterly has been

*McConnell, R. G.: "Whitehorse Copper Belt"; Geol. Surv., Canada, 1909.

**McConnell lists tremolite as one of the gangue minerals of the deposits. It seems probable that this is a mistaken identification for wollastonite.

under the able direction of T. H. Kerruish, who has had experience in several of the Whitehorse properties and is fully conversant with the problems and difficulties attending their successful exploitation.

On the Pueblo, eleven holes, Nos. 1 to 10 and No. 21, have been drilled west of the old workings. The cores of these holes were not available for inspection to the writer, but from information supplied it is understood that holes Nos. 1, 5, 6, and 21 encountered ore at depths varying from 250 to 300 feet. Hole No. 1 is reported to have encountered 23 feet of cuprite ore at a depth of 250 feet; hole No. 5, 16 feet of ore; and hole No. 6, 14 feet of ore at depths of about 300 feet. Hole No. 21 encountered ore at 61 and 331 feet. The data furnished by these holes are not sufficient to permit calculating the strike, dip, and thickness of the ore-bodies encountered. As some of the holes are blanks it is evident that further drilling, or development work, must be done before any satisfactory calculation of tonnage can be made. Nevertheless, an ore-body lying west of the old workings is indicated.

North of the old workings, drill holes Nos. 16 to 20 indicate an ore-body trending at right angles to the former Pueblo lode. This newly discovered body was encountered in two holes; two of the other three holes showed mineralization, but no commercial ore. As before, the data are not sufficient to indicate the essential facts with regard to this body, and further drilling must be done before the available tonnage may be calculated. The indicated ore differs radically from the ore of the Pueblo lode; it has a silicate gangue, in contrast with the Pueblo hematite body.

The Tamarack-Carlisle property lies east of, but on the same altered zone as, the Copper King mine, the last of the Whitehorse properties to be worked prior to the Richmond Yukon Company venture. This altered zone is apparently an inclusion of limestone in the granitic intrusives. The limestone is highly altered, silicate minerals, such as garnet and epidote, and also copper sulphides having been introduced. At the time of the writer's visit the Carlisle workings were largely filled with water, but from descriptions by the management, a shaft 140 feet deep, partly vertical and partly inclined, has been sunk on the ore-body, with levels at 50, 98, and 134 feet. The upper workings were driven by the former management and on them was encountered a shoot of ore which has been largely removed by stoping. The lowest level also encountered a shoot of ore, which is apparently lenticular in shape, ending upwards on the second level, and having on the lower level a length of about 90 feet, with a maximum width of 20 feet. From the lower level crosscuts were run, and diamond drill holes were spread out fanwise below the level. These pierced the ore-body below the level. The east drift and south crosscut of the third level terminate in granite.

The altered zone extends some distance north of the shaft. In this area the introduction of silicate minerals into the limestone is quite marked, thus making this ground a favourable zone for prospecting. The depth to which the limestone inclusion and, consequently, the mineralization, extends, has not been tested. It would be somewhat difficult at this locality to determine the extent, in depth, of the limestone, owing to the fact that there is an interfingering of the granite and limestone, so that it is difficult to determine if the main mass of intrusives has been reached unless the drill holes penetrate some considerable distance into granite.

The War Eagle has a number of showings; the main workings are on the largest of these, which is a lens 45 feet wide. On this a shaft has been sunk to a depth of about 70 feet, with levels at 13, 33, and 50 feet, and a crosscut to the west at the bottom of the shaft.

To the north of the main ore-body, a vertical shaft has been sunk on a hematite magnetite body, which is apparently slightly off the strike of the main zone, and may be situated in a cross fracture. This shaft was full of water at the time of the writer's visit, and, consequently, was not open to inspection. To the west of this shaft, on the strike of the main zone, there is an open-cut with a showing of mineral. To the south of the main shaft, and situated along the main ore zone, a lens of high-grade ore has been partly removed by means of an open-cut. There are several small showings on the property.

The main showing is 125 feet long, 45 to 55 feet wide, and consists of two streaks of ore with a barren or low-grade streak between. The ore-bearing streaks are 18 and 25 feet wide on the first level and the barren or low-grade streak 12 feet wide. South of the main shaft, the eastern streak of ore has been stoped, apparently from the third level, to the surface. The third level is blocked with ice, and ice extended in the stopes almost up to the second level, making it impossible to determine the exact amount of stoping done. North of the shaft both streaks have been to some extent stoped from the first level upwards; but are untouched below. McConnell obtained an average of 2·7 per cent copper across the whole lens, including the barren or low-grade streak; but the average in the upper workings has since been reduced by the removal of much of the high-grade ore. The writer took three samples: Nos. 1 and 2 of the east and west streaks of ore, respectively, and No. 3 of a cut along the hanging-wall of the old stope in the second level. These were assayed with the following results.

Sample No.	Silver, ozs. per ton	Copper, per cent
1	1·31	1·53
2	2·95	9·34
3	2·40	1·65

These samples cannot be regarded as other than merely indications of what the ore-body may contain. The number of samples is not sufficient, in an ore-body of this character, to give average results, and from all the workings sampled a certain amount of ore has been removed.

The work of Richmond Yukon Company to October 1, 1927, consisted of drilling an inclined hole to the west of the ore-body in order to tap the high-grade body visible in the south open-cut; and in cleaning out the shaft and levels preparatory to underground drilling during the winter.

The drill hole encountered ore about 100 feet from the surface, but failed to reveal any ore beneath the open-cut, though it passed through an altered zone, with some specks of mineral, at the depth calculated to be beneath the ore-body.

When the Pueblo mine was formerly operated a spur line connected it with the main line of the White Pass and Yukon route. The spur line is no longer ready for use, as many of the fills have been washed out, the cuts sloughed, and replacements and repairs are needed on ties, bridges, and culverts. It would require considerable money to place this spur line and the ore bunkers at Skagway in shape for handling crude ore. On the other hand, ore and concentrates sacked, receive the favourable rate, in carload lots, of $5.25 a ton from Whitehorse to Seattle, Tacoma, or San Francisco, and with the use of caterpillar tractors or trucks, the item of transporting the ore to Whitehorse would not be unduly heavy.

The silicate ores such as those of the Carlisle and War Eagle are readily amenable to concentration. The hematite ores of the Pueblo, on the other hand, would probably have to be shipped as mined, but this would be compensated in part by preferential smelting rates.

One essential fact with regard to the Whitehorse deposits must be kept in mind, namely, that the deposits are of the contact metamorphic type, and consist usually of disconnected lenses, situated near the contacts of the limestone with the intrusives. One lens does not necessarily lead to another, and in general each lens does not form a large ore-body. The costs of development and mining under such conditions must, undoubtedly, be high.

To what depths values, and consequently mining, may be reasonably expected to extend has never been determined. It may be safely assumed that the values will not extend far below the lower contact of the limestone with the granite, and the depths to which these limestones extend probably differ from area to area within the field.

1928

Introductory Note

The following note, by G. A. Young, Chief Geologist, with reference to field work in Yukon Territory in 1928, is included in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1929, pages 9 and 10:

"W. E. Cockfield mapped geologically and topographically the drainage basin of Little Salmon River, southern Yukon. The area examined is 100 miles long by 5 to 20 miles wide. An apparently small deposit of silver-lead ore a few miles from the head of Little Salmon Lake indicates that the district is mineralized and that other deposits of the same type may be present. A report upon the district, accompanied by a geological map, appears in Summary Report 1928, Part A."

LITTLE SALMON AREA

by W. E. Cockfield

Little Salmon area includes that part of Yukon territory drained by Little Salmon river. It lies between latitudes 62° and 62° 30′ and longitudes 133° and 135° 45′, being bounded on the west by Lewes river and on the east by Pelly river. The only settlement within the area is Little Salmon village, on Lewes river about 180 miles north of Whitehorse and 45 miles south of Carmacks. The river steamers of the White Pass and Yukon route pass Little Salmon village at regular intervals during the summer months. In the winter, the course of Little Salmon river is followed as a regular route between Ross River post and points on Lewes river. Thus the district has been known for a considerable time; but details as shown on existing maps proved to be incorrect. Little Salmon village at one time consisted of a trading post, an Anglican mission, and an Indian village, but it is now deserted for the greater part of the year.

Access to the area is afforded either by means of a foot trail or by boat using Little Salmon river as a route. The foot trail follows the course of the river fairly closely, but it was found to be in extremely poor condition and difficult to follow, as repeated bush fires had either caused it to become choked with windfall or in some cases had entirely obliterated it through the destruction of every vestige of vegetation. Considerable time had, therefore, to be devoted to cutting a trail suitable for use by pack animals, and at the close of the field season this trail was in fairly good condition from Little Salmon village to the upper canyon. Except in two instances, the trail is never very far from the river. About 2 miles from the head of the lower canyon the trail leaves the river for a distance of 4 miles, saving in this distance nearly 10 miles travel along the banks of the stream. Three miles below Little Salmon lake the trail follows up Bearfeed creek, and cutting through a pass in the hills, again enters the valley of Bearfeed creek which it follows to its head. At this point it climbs to the plateau surface and then drops to the valley of Drury creek, which it follows to Little Salmon lake. This part of the trail adds nearly 10 miles to the distance to be travelled, but it would be impossible to secure a pack trail around the shores of Little Salmon lake. From the head of the lake to the upper canyon the trail is never very far from the river. Near the upper canyon it swings away from the river and crosses to Pelly river along a series of small lakes.

Little Salmon river itself offers a fair route into the district. It may be navigated by boats of shallow draught either by poling or with outboard motors for power. Except in the lower 10 miles the river presents few obstacles to navigation; this stretch of the river, however, known as the lower canyon, is swift throughout, with certain riffles of much faster water. The river is narrow and crooked, with numerous hairpin bends and overhanging trees or sweepers, and a large number of boulders and a few log jams add considerably to the difficulties of navigation. A boat of good power can ascend without great difficulty all but perhaps a few stretches of the fastest water. In low water the current in this stretch is much slacker, but lining would probably be necessary on some of the bars. From the head of the lower canyon for 3 miles upstream the current is still swift, but the river is much straighter so as to offer no great obstacles to navigation. Thirteen miles above the mouth there is a rapid. The channel is towards the left hand bank proceeding upstream. In high water the current at this rapid is probably swift enough to require lining, but in medium stages of water it can be ascended without difficulty. From the head of this rapid to the mouth of Bearfeed creek, i.e. 4 miles below Little Salmon lake, the current is much more sluggish, and the water is deep. A few riffles with fast water occur, but this stretch as a whole offers no difficulties to boats of good power. Four miles below Little Salmon lake a short rapid occurs and the channel is again towards the left bank proceeding upstream. Above this the river widens out to a lake-like expansion with a sluggish current, and with the bed of the stream overgrown with water grasses and weeds through which it is at times difficult to find a channel. The total distance from Little Salmon village to Little Salmon lake is 45 miles by river, and 28 miles by trail.

Little Salmon lake is 21 miles long and slightly over a mile wide. Almost throughout its length it is bordered by rocky shores and in some cases by rock cliffs which rise 15 to 20 feet above the water. The valley walls rise abruptly from the lake to a marked shoulder, whence they slope more gradually to the summits of the upland surface. From the experience gained during the season, which is confirmed to some extent by the Indians, it may be stated in general that the lake is not subject to the sudden and violent storms that are characteristic of the large lakes of southern Yukon, and there are probably few days during the summer when it would be unsafe to travel the lake in the small boats used for river work. In general it was found that windstorms usually died away at sundown.

Above the lake, Magundy river is reported to be navigable for about 20 miles in high water. The same point, however, may be reached in 7 or 8 miles by trail. This part of the river was not examined during the course of the work, save for a short distance above the lake, where the current was sufficiently slack in low water to allow a boat to be rowed against it. From 8 miles up the valley above the lake, Magundy river shoals rapidly, and there are numerous bars or riffles of fast water.

Topography

Little Salmon area lies within the region known as Yukon plateau, which has so frequently been described that no lengthy description need here be given. In general it consists of broad, flat, gently undulating upland surfaces, separated by deeply cut valleys. The upland surface stands at 5,000 to 5,500 feet above sea-level. A number of isolated peaks and mountain ranges rise somewhat above the general level. Near the major valleys, the upland surface has been maturely dissected. This is true also in the case of Little Salmon area, in the vicinity of Lewes and Little Salmon valleys, which are usually fronted by low hills that do not rise above timberline (4,500 feet). The elevation of the summits of these hills is, therefore, 1,000 feet below the plateau surface. When Little Salmon lake is reached, the character of the valley changes to a marked degree. The valley walls rise abruptly from the lake to a marked topographic unconformity, or shoulder, whence the slope is more gentle to the upland surface. Above the lake the hills still rise steeply from the valley, but the continuity of the plateau surface is interrupted by the Glenlyon range. To the north of Little Salmon valley is a second valley which occurs along the foot of Glenlyon range. This is occupied in part by Drury lake and Drury creek.

Little Salmon valley extends in a fairly straight line from Lewes to Pelly rivers. It is an old valley which is only occupied in part by Little Salmon river and its upper continuation, Magundy river. Near Pelly river, Magundy river enters this valley through a canyon after flowing parallel with Pelly river for some distance. Thirteen miles from Little Salmon village, Little Salmon river leaves this older valley to enter Lewes river through the lower canyon. This older valley with canyons above and below suggests changes in drainage following glaciation. The area has been, to a large extent, heavily glaciated. The exact extent of the ice was not determined, but it is probable that the greater part of the older valley referred to was occupied by ice. Many of the hills on the north side of the valley have a typical *roches moutonnées* effect and 7 miles below Little Salmon lake a terminal moraine 3 miles long occupies the valley. Throughout its length from Little Salmon lake to the mouth, the river is bordered by high, gravel benches that represent in part glacial drift, and probably in part glaciofluvial accumulations, through which the river has cut to depths of 100 feet or more.

One feature of Little Salmon district that deserves attention is the difficulty of putting a road into the district should such be desired for mining operations. A road could be constructed without great difficulty as far as Little Salmon lake, although this would require a great deal of heavy grading work as a number of deeply cut gulches cross the high benches that a road would naturally follow. The cost of building a road around Little Salmon lake would be prohibitive, as a very great deal of rock-cutting would be entailed.

The timber of the area has been largely destroyed by repeated bush fires. Some stands of timber remain on the northern slope, that is, the southern side of the valley, where the ground as a rule is swampy, particularly along Little Salmon lake; but as a whole there is little green timber left in the area.

General Geology

The rocks of Little Salmon area include sedimentary, igneous, and metamorphic types. Of these the latter two types occupy the greater part of the area, the sediments occurring as a fringe along the western border and as isolated patches along the eastern border. For this reason, the lack of sedimentary horizon markers, the ages of the various rocks in the district are difficult to determine. In general the rock types found correspond closely with those of other districts in southern Yukon, and it may be stated at the outset that little new evidence with regard to ages of different formations was obtained. Perhaps the outstanding feature from a geological point of view was the discovery of fossils that may be classed with some assurance as Triassic. In southern Yukon fossils have been collected hitherto which were supposed to be Triassic, but the determinations were always doubtful. The fossils obtained last summer lead to the belief that the marine Triassic in southern Yukon is possibly much more widespread than has generally been supposed. The following table gives the formations present and their relative ages where known.

Table of Formations

	Recent and Pleistocene	Recent alluvium and glacial drift
Tertiary (?)........	....	Quartz porphyry
	....	Granodiorite and related rocks
Mesozoic...........	....	Andesite, tuff, and breccia
	Upper Triassic and, probably, Jurassic	Conglomerate, argillite
Palæozoic..........	Carboniferous (?) and, possibly, Triassic	Limestone
	Carboniferous and, or, Older..	Serpentine
Precambrian (?).....	....	Quartzite, mica schist, chlorite schist, and crystalline limestone

Schist Complex

The oldest rocks of the area are a group of metamorphic rocks, consisting of quartzite, mica schist, chlorite schist, and crystalline limestone. The quartzites are dark grey, green, mauve, or white, and as a rule are massively bedded, breaking up into large blocks which are a characteristic feature of the upland surface wherever these rocks occur. Close examination reveals an abundance of secondary mica, which gives to the rock a gneissoid appearance. Grey mica schist and greenish chlorite schist are interbedded with the quartzites. Where the mica schists are abundant they include beds or bands of crystalline limestone. These appear for the most part to be small, discontinuous lenses of impure limestone, which is in most cases dark brown or yellow due to staining with iron oxide. The schist group is well developed on both sides of Little Salmon lake and extends northward to Glenlyon mountains, and continues up the valley of Magundy river to Pelly river. In the part of the group exposed about the lower half of Little Salmon lake and on the hills to the north of it, quartzite and schist are most abundant, but passing up the lake and up Magundy valley, limestone bands become more prominent, until at a point 7 miles above the lake several hills, facing the valley, are composed entirely of limestone. Above this again there are several exposures of fairly thick limestones. This abundant development of limestone in the schist group has not been noted elsewhere in Yukon. A careful search was made over large areas of these limestones for fossils, without results, and it also became apparent that these larger developments of limestone were also interbedded with schist and, therefore, to be included in the schist group.

The structures of the schist group are exceedingly complicated and it would require much more detailed study than could be devoted to them to determine even the major features. Rapid changes of strike and direction of dip, combined with the prevailing steep dips, bear witness to intense and complex folding and probably faulting. No definite evidence as to the age of these rocks was obtained. They are undoubtedly older than the igneous rocks of the district, which cut them, and they have undoubtedly been subjected to folding and metamorphism that the older sedimentary rocks have escaped. For these reasons they are regarded as the oldest rocks of the area, and as investigations in other parts of Yukon have shown the schistose rocks there to be Precambrian, the schist group of Little Salmon area has also been classed in that era.

Serpentine

Only one small area of serpentine was noted in place, namely on the ridge south of Drury lake, but float in other parts of the area renders it fairly certain that there are other occurrences that were not found. It is a dense green to black rock with a greasy lustre, traversed in many cases by small veinlets of asbestos, which although of scientific interest are too small and insufficiently numerous to prove an economic source of that mineral. The relationship of the serpentine to the schist group was masked at its single occurrence by superficial accumulations; as it is, however, entirely surrounded by schist it seems probable that it represents a basic igneous intrusive since converted into serpentine. The specimens selected for examination proved to be wholly serpentine with veinlets of asbestos, and do not afford any clues as to the original character of the rock. This rock is similar to the 'Gold Series' of Atlin district, which may be considered Palæozoic and possibly Carboniferous. On the other hand it might be correlated with the 'Moosehide diabase' of Klondike district, the age of which is uncertain. Cairnes classes certain pyroxenites and peridotites of Wheaton district as Devonian, but as evidence of age is distinctly lacking in Little Salmon district, the serpentine has been classed as Palæozoic, Carboniferous, or older.

Limestone

Limestone occurs in patches and bands in the andesite of the lower canyon of Little Salmon river, and at a few points above the canyon. These bands are seldom more than 500 feet wide, and as they are partly covered it is in many cases difficult to trace individual bands. The bedding is in most cases obscure, and difficult or impossible to detect. One prominent band crosses Little Salmon river near the head of the lower canyon, appearing as a series of outcrops that give the appearance of belonging to the same band. This is in part a fault breccia, recemented with calcite. The limestone is grey, compact, and largely, if not wholly, recrystallized. A careful search of what was assumed to be a single band of limestone resulted in the discovery of only two fossils, which were submitted to E. M. Kindle and F. H. McLearn for identification. One of these, Mr. Kindle reports, "belongs to the Zaphrentid group of genera, possible *Hapsiphyllum*, and affords satisfactory evidence of the Palæozoic age of the formation represented. Until more evidence is presented I would advise referring the beds represented to the Carboniferous as a provisional disposition of them". The second coral was determined to be not a Palæozoic form. Mr. McLearn reports it to be too poor for identification; it may be *Isastrea* with a Mesozoic correlation. These corals were obtained some distance apart on what was believed to be the same band of limestone; but as the outcrops are not continuous and with the evidence of faulting previously cited, it would appear that there are two limestones, one of Carboniferous(?) age and the other of Triassic(?) age. As these cannot be separated in the field without adequate faunal evidence they are grouped on the map under one pattern as Palæozoic limestone, but it should be remembered that Mesozoic limestone probably is also present.

Conglomerate and Argillite

The rocks of this group compose the hill facing Lewes river north of Little Salmon village, and continue up the northern bank of Little Salmon river nearly to the head of the lower canyon. Exposures are not numerous except along the summits of the hills and on the benches of the river. The conglomerates were found along the lower part of the river and as they have been traced continuously from one of the type areas, namely Carmacks area, along the banks of Lewes river, they are unhesitatingly classed with the Laberge beds. The conglomerates are massively bedded with cobbles and boulders of granite, andesite, and rocks of the schist group embedded in a tuffaceous matrix. The bedding is best seen from a distance; close at hand it is quite obscure. Towards the upper end of the lower canyon a few exposures of black to dark grey argillite were noted, which have been jointed and sheared so that the bedding is indistinguishable. Fossils were obtained from one of these outcrops. These were determined by Mr. McLearn to be flattened and fragmentary specimens of *Pseudomonotis subcircularis* (?), with a probable correlation with upper Noric of the Upper Triassic. The age of the Laberge beds has been determined in Whitehorse district to be Lower Jurassic to lower Middle Jurassic; with the probability of a somewhat greater range. It seems apparent that the argillites found in Little Salmon area do not, therefore, belong in the Laberge beds, but constitute an underlying formation. Occasional fossils that were believed to be Triassic forms have been heretofore found in southern Yukon, in all cases in limestone, but always the poor state of preservation precluded a definite age determination. It would now appear to be fairly definitely established that marine Triassic does occur in southern Yukon, and if the previous somewhat indefinite determinations be accepted the marine Triassic is much more widespread in southern Yukon than was formerly believed to be the case. It is also possible that some marine Triassic has been included with the Laberge beds in other sections. Detailed studies will probably be necessary at a number of points before the succession can be established. For mapping purposes the Triassic and Jurassic have been included under the one pattern on Map 227A accompanying this report.

Andesite, Tuff, and Breccia

A large area in the lower part of Little Salmon valley is floored with andesites, andesite tuff, and breccia. These rocks exhibit a variety of colours, usually red or green, and they vary greatly in texture. Some are aphanitic, others are porphyritic, and still others amygdaloidal, with the amygdules filled with quartz, calcite, or more rarely zeolites. The tuffaceous phases resemble greatly the matrix of the conglomerate of the Laberge beds, and phases of the latter, where pebbles are absent, cannot be distinguished from the tuffs here included. The andesites, however, are in part at least younger than the Laberge beds, for it has been found, where they have been studied in detail, that they cut the Laberge beds. No new evidence on this point was obtained in Little Salmon area. The andesites here described are probably in part intrusive and in part extrusive. Remnants of Carboniferous or Triassic limestone occur in them and elsewhere it has been found that some of them cut the Laberge beds and in turn are cut by granitic intrusions of the Coast Range batholith. They may thus be partly contemporaneous with the Laberge beds and partly later and may be referred to the Jurassic.

Granodiorite

These are grey to pink rocks, of a granitic habit, usually coarse in grain, with feldspar crystals in many cases up to 1 inch or 2 inches in length. They resemble closely in lithological characters the intrusives of the Coast Range batholith, and also granitic intrusives which occur at many places throughout the plateau. In Little Salmon area several small bodies of these intrusives occur in the vicinity of Little Salmon lake. The main occurrence, however, is in Glenlyon range. Only a small part of the western contact of these intrusives of Glenlyon range was examined during the field season, but from work that has already been done by McConnell on Pelly river, and from what could be seen from the hills facing Glenlyon range, these mountains are apparently underlain by granitic intrusives throughout their length, and in reality form a batholith at least 75 miles long, stretching from near the junction of Pelly and Macmillan rivers to Little Salmon river, and possibly extending farther both northwest and southeast than indicated by the present known limits. This body has a maximum width of 16 miles and narrows rapidly towards the northwest. It has a northwesterly trend, thus corresponding to the trend of the major structural features of Yukon. It is proposed to call this body the Glenlyon batholith. It crosses Magundy river at one point where it has a width of about 4 miles, but its southeastern extent from the valley could not be seen. The age of these bodies of granitic intrusives which occur within the plateau region has never been satisfactorily determined. They have usually been correlated with the Coast Range intrusives, but definite evidence as to their age is lacking. In Little Salmon area they cut andesites which are believed to be, in part at least, more recent than Lower Jurassic. Consequently they may be considered as related to the Coast Range batholith, i.e. Upper Jurassic, or they may possibly be younger, extending into the Cretaceous.

Quartz Porphyry

Rocks of this type are not abundant in Little Salmon area. One small body was found cutting schist close to the margin of the granitic intrusives, and a few dykes cutting andesite occur near the margin of one of the smaller granitic masses. Typically these are light yellow to brown rocks with a fine-grained matrix with phenocrysts of quartz, and occasional crystals of feldspar. These are the youngest consolidated rocks of the area. Elsewhere similar rocks have been classed as Tertiary, and as no new evidence has been obtained they are also in this report referred to that era.

Overlying all the consolidated rock formations is a mantle of alluvium and glacial drift. This consists of soil, talus, rock debris, silt, sand, gravel, boulder clay, and volcanic ash. The accumulations in the valleys are thickest, and where their thickness is such as to render it difficult or impossible to inspect the underlying bedrock by ordinary prospecting methods, they have been mapped. On the upland surface and hillsides numbers of rock exposures permit of making an estimate of the type of rock underlying the soil covering. The accumulations in the valley bottoms are in places at least 100 feet thick, as the rivers have exposed sections of this thickness of these unconsolidated materials, without cutting through to bedrock.

Economic Geology

Mineral Deposits

So far as is known to the writer there are no claims in good standing in Little Salmon area. Although the area has been travelled to a considerable extent by both white men and Indians, it would appear to have received very little attention from the prospector. The reasons for this are not apparent. The country at the present time is undoubtedly difficult to travel owing to the large amount of windfall, but this condition did not always exist, and the ease with which central points in the district may be reached by water, overcomes the difficulty to some extent. The fact that the district has furnished a winter, rather than a summer, route, may possibly in some measure account for the lack of prospecting. The only deposit brought to the attention of the writer was an occurrence of silver-lead ore, which has been known for a long time to the Indians who travel through the district. Another deposit of silver-lead ore is reported to occur to the south of the area mapped, but definite information with regard to this could not be secured.

The occurrence shown to the writer by the Indians lies about 7 miles from the head of Little Salmon lake, near the head of the first large creek entering Magundy river from the north. There is no trail to the deposit, which, however, lies close to a route used by the Indians while hunting between Little Salmon lake and Pelly river. The mineral showings occur in a line of small cliffs at the pass near the head of the creek.

The country rock in the vicinity consists of schist with a small intrusion of quartz porphyry. Owing to poor exposures the form of this intrusion could not be ascertained. There are a number of showings, none of which is well exposed, being mostly covered with talus from the cliffs. The best exposure consisted of a vein cutting schist having a strike of south 80 degrees east and a dip of about 45 degrees to the southwest. The vein could be traced up the cliffs from the talus below for a length of about 80 feet; the part exposed in the cliff face being probably the narrowest part of the vein. At the top of the cliffs it had a width of 6 inches; at the base the width was judged to be about 2 feet. On the flat above the top of the cliff the vein was covered by overburden so that it could not be told whether the vein continued or pinched out immediately. No float was found on this flat. The mineralization consists of galena and zinc blende with siderite, quartz, chalcopyrite, and pyrite. At the widest part of the vein noted, there was 2 to 6 inches of more or less massive galena along the foot-wall of the vein, followed by about 10 inches of disseminated galena. The remainder of the vein was apparently barren. On the cliff face a seam of about 2 inches of galena occurred at the foot-wall, with occasional small masses of galena elsewhere in the vein. A sample was cut across the best mineralized showing that could be found; including only those parts showing some galena mineralization. This sample had a width of one foot and assayed* as follows:

Gold................................	none
Silver................................	23·53 ozs. per ton
Lead................................	48·76 per cent
Zinc................................	1·60 "

A second showing occurs about 25 feet southwest of the first. This is apparently in the form of a lens having a maximum width of 6 feet and an estimated length of about 40 feet. The galena mineralization is apparently much more scanty than in the first showing. The minerals noted in place were quartz, siderite, and zinc blende, but float from this lens showed some black manganese oxide, pyrite, and galena, demonstrating that these minerals do occur.

The intrusion of quartz porphyry occurs below these showings. Below this again, near the creek level, are a number of occurrences of iron oxide, carrying pyrite and chalcopyrite. The amount of overburden in this vicinity precluded the securing of definite data with regard to these.

A considerable amount of work would have to be done on these deposits before a clear idea of their character and extent could be obtained. From what can be seen at present, the writer would judge that the individual occurrences are quite small and the assay taken shows that they do not carry any considerable amounts of silver. It may be taken that unless deposits of much greater size than indicated by those seen are discovered, attempts at mining would not be justified, as the cost of putting a road into the district for mining purposes would be considerable. The deposits are of interest, however, in indicating that mineralization has taken place in Little Salmon area, and that this mineralization lies near the border of the Glenlyon batholith. This batholith, as already pointed out, extends from Little Salmon river to near the junction of Pelly and Macmillan rivers; and it may possibly extend farther southeast and nothwest beyond its present known limits. Its eastern border lies along Pelly river for a large part of this distance and is consequently easy of access; its western border is more difficult to reach and extends in part along Drury lake where the batholith is widest. Towards its northern end the batholith apparently narrows, so that both borders may be readily reached from Pelly river. The schists to the south of Drury lake, i.e. along the contact of the granodiorite, hold numerous quartz veins. Where examined these proved to be barren of sulphides.

With regard to placer gold, the areas bordering the batholith might be classed as reasonably favourable, were it not for other factors which tend to destroy the value of deposits of this type. As already pointed out parts of Little Salmon area have been intensely glaciated, and these are the very parts in which placer deposits most likely might have formed. This

*Assay by Mines Branch, Dept. of Mines, Ottawa.

glaciation would not only tend to destroy concentrations of gold in the form of placers, but would also tend to bring any remnants beneath a deep layer of glacial drift. Consequently the region cannot be looked upon as favourable to deposits of this type.

Coal

The rocks of the Laberge beds contain coal at many points in Yukon. A narrow fringe of these rocks occurs on Lewes river and a few isolated outcrops occur near Pelly river. Owing to the lack of definite horizon markers, it is impossible to say whether the coal-bearing horizons are present or not.

1929

Introductory Note

The following note, by G. A. Young, Chief Geologist, incorporated in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1930, page 12, relates to field work in 1929 in Yukon Territory:

"W. E. Cockfield, assisted by E. J. Lees, commenced the topographical and geological mapping of Laberge quadrangle (latitudes 61 degrees to 62 degrees, longitudes 134 degrees to 136 degrees), southern Yukon. Silver-lead, placer gold and, possibly, copper-bearing deposits, occur within the map-area. The work, when completed, will result in the publication of a geological and topographical map, on a scale of 4 miles to 1 inch.

"During the field season, Cockfield visited several of the active mining camps of Yukon and will report upon them in Summary Report 1929, Part A. An effort will be made to continue annually this review of mineral developments on Yukon."

THE MINING INDUSTRY OF YUKON, 1929

by W. E. Cockfield

About six weeks of the regular field season of 1929 was devoted to a general survey of the mining industry of Yukon. The industry enjoyed a rather satisfactory year in 1929. Although no new camps of importance were discovered and several development schemes in some of the older camps proved to be disappointing, yet production from the established camps was maintained at a high level, and in the case of lode mining in the Mayo camp, was even slightly increased.

Placer Operations

Klondike District

In Klondike district production of placer gold was maintained at a high level. Four dredges were at work for the greater part of the summer, and the company operating these, Yukon Consolidated Gold Company, was actively engaged in refitting a fifth, which it hoped to place in operation before the end of the summer. Two of the dredges operating were on the flats of Klondike river, between the mouths of Bonanza and Hunker creeks. These are dredges of large capacity having a daily capacity of 10,000 cubic yards, and are electrically driven. The other two dredges operated on Dominion creek, one at Cariboo and the other at Granville. These are boats of smaller capacity, having a yardage of about 3,500 cubic yards apiece daily. The Yukon Consolidated Gold Company also operated hydraulic plants at Jackson gulch on the Klondike, and on Lovett gulch on Bonanza creek. In addition to this work, the company, to secure adequate power for extending its operations in the future, undertook the digging of a ditch to bring the water of the Klondike to the power plant now using the water from the North fork of the Klondike.

Gold production was augmented to some extent by a number of individuals, working chiefly on Bonanza and Hunker creeks. The gold production from this source probably will not exceed 5 per cent of the total. Figures for the production of the Klondike are not available, but it is estimated from reliable sources that for 1929 they will probably prove to be slightly in excess of $600,000.

The amount of ground still available for dredging in the Klondike is difficult to estimate. Lowering of costs may in the future increase the available ground, as has been the case in the past. The method of thawing with cold water in the place of steam has on the whole considerably cheapened the cost of thawing and made available ground which could not be considered before. Whether there will be other advances in dredging practice that will prolong the life of the camp is impossible to predict. It seems certain, however, that there is still available to the company very considerable ground, particularly on the Dominion slope, that can be dredged profitably under present conditions.

Other Districts

There has not been a great deal of activity in placer mining in other districts. On Sixtymile river, a dredge which had lain idle for about 12 years was refitted, and started operating late in the summer, between Glacier and Miller creeks. The ground ahead of this dredge has been only partly prospected as it was intended to prospect with the dredge itself. The early results of dredging were reported to be quite satisfactory. This dredge is a steam-operated boat of the smaller type.

On Thistle creek, Manley and Logan did a certain amount of work, largely stripping, as a preliminary to sluicing; but no washing for gold took place.

On Squaw creek, in Dezadeash Lake section, there was not a great deal of activity. Most of the ground is still held by Indians, who were the original locators and are unlikely to accomplish much in the way of mining.

Lode Mining

Klondike District

In Klondike district the only development in lode mining was the attempt to reopen, by means of local capital, the Lone Star. This property was operated a number of years ago, and for a period of four months milling of the ore showed recoveries running from $3.69 to $3.90 a ton. These values are considerably in excess of those shown by the sampling of the property by T. A. MacLean*, and it was claimed that the values contained in the sulphides were not recovered as the mill was equipped to recover only the free gold.

The property is situated on the eastern slope of Victoria gulch, a tributary of Bonanza creek, and may be reached by road from Dawson, the distance being about 25 miles. The road is normally in fair condition, and an automobile can be taken right to the property.

The deposit is not a definite vein or lode. It consists of a crushed zone in the schists of the Klondike series, with veins, bunches, and masses of quartz developed along the zone. These are very plentiful, and MacLean estimated that they make up about 20 to 25 per cent of the mass of the country rock in this vicinity. Accompanying these bodies of quartz are feldspar, pyrite, and galena, with occasional specks of chalcopyrite, and

*MacLean, T. A.: "Lode Mining in Yukon"; Mines Branch, Dept. of Mines, Ottawa, 1914, pp. 20-31.

small amounts of free gold in particles large enough to be visible to the naked eye. From the work already done, and from samples taken, it appears that the values are not confined to the quartz, but extend into the schists on either side of the quartz bodies. There are no definite walls to the deposit. Mining has been carried on for widths ranging from 15 to 35 feet, and it has not been established that the values are confined even to these widths.

The main workings have been divided into two groups, those driven before 1911 and those made since that date. Prior to 1911 there was a main tunnel about 300 feet long which cut a rather persistent quartz vein known as the Carthy ledge at 225 feet with a drift to the north into the main zone. This encountered a clay zone which was explored by several crosscuts. From a point about 150 feet from the portal in the main tunnel there is a crosscut to the south to the Carthy vein which drifts to the north and south along this vein; the northern drift being connected to a shaft from the surface and the southern drift being terminated by a 42-foot winze. Several shallow shafts to the northwest of these workings complete the work done prior to 1911, all of which are now inaccessible as they are partly caved and partly filled with water.

The workings driven since 1911 consist of an open-cut about 350 feet long, 12 to 14 feet wide, and 30 feet deep, from which the ore that was milled was taken. There is also a drift now caved, from the open-cut into the foot-wall side of the mineral zone, and a shaft 22 feet deep with a drift 65 feet long at the bottom. These latter workings are filled with water. It was in these that the company secured some rather high, but erratically distributed, values, as a result of sampling during the driving of these workings.

At the present time the company is driving an adit to hit the mineral zone, and intends to drift along it to the north until under the workings mentioned above, to which a raise will be driven to drain them. At the time of the writer's visit, this adit had encountered the Carthy lode, thus proving its continuity to the south, but had not entered the main mineral zone beyond.

As pointed out before, sampling did not demonstrate commercial ore on the property; but mill run recovered values far in excess of that indicated by sampling. This, however, can hardly be cited as an argument against sampling, and in spite of past results, the writer is of the opinion that careful, systematic sampling is the only method to test properly this deposit, but the samples should be cut at very small intervals, owing to the occurrence of free gold. The problem is to determine if commercial ore exists over reasonable mining widths. If it be established that this zone contains commercial ore-bodies, there is no doubt whatever that other similar zones exist in the neighbourhood, for the amount of quartz in the schists is very high. Quartz bodies have been found in a number of open-cuts on the property, and there is a good deal of quartz float generally on the hill.

Mayo District

Mayo district had on the whole a very satisfactory year. No new areas of importance were discovered, but developments in the better established camps were encouraging, and production was slightly increased, amounting to about 8,300 tons of ore and concentrates. Although exact figures as to the metal content are not available at the time of writing, it is believed that they will constitute a record for the camp. In 1924, when

Keno Hill, Limited, withdrew from the camp, and Treadwell Yukon Company, Limited, began milling its ores, there was a falling off in tonnage of shipments, but since then the tonnage has been increasing year by year until last year the tonnage shipped about equalled the combined tonnage of the two companies in 1923. The metal content, however, is much higher, as a very considerable part of the shipments are now composed of concentrates running higher in silver than the crude ore which was formerly shipped.

The producing area for the year centred about Keno hill. The major mining operations are being carried on by Treadwell Yukon, Limited. This company owns the Ladue mine situated on the western slope of Keno hill at an elevation of about 4,000 feet, and is also operating under lease from Keno Hill, Limited, the adjoining property known as the Sadie mine. The two are being worked as one mine. Treadwell Yukon Company, Limited, has also pursued a campaign of developing likely looking prospects in the vicinity, and this policy has been meeting with marked success. Four properties have been acquired either by purchase or under option, and good progress has been made in developing them. These properties are the Lucky Queen, Silver King, Arctic, and Elsa groups. All these, with the exception of the Lucky Queen, are situated on Galena hill.

For a general description of the geology and ore deposits the reader is referred to previous work by Stockwell* and Cockfield**.

On the *Sadie* and *Ladue* groups work has been very much extended since the properties were last described. A drainage tunnel over 3,000 feet in length has been driven to tap the vein, and about 900 feet of drifting done on the 600-level where the tunnel entered the vein. A raise to connect with No. 2 shaft has been made, and the 400-level driven about 750 feet north of the shaft, and south into the Sadie workings, a distance of about 2,500 feet. The 200-level has also been extended into the Sadie. In all this work very little ore was encountered that extended below the 400-foot level. The vein has a maximum thickness of 70 feet, but the average thickness is probably about 7 to 8 feet. The mineralization is a siderite gangue, with galena, freibergite, and zinc blende as the important ore minerals. Small amounts of native silver and pyrargyrite also occur, as well as quartz, arsenopyrite, pyrite, and chalcopyrite. The vein is one of the main longitudinal fractures of the area. Beyond the workings to the north it appears to become lost in a clay zone, probably as the result of the brecciation of the schist, and it has not been traced to the south beyond the limits of the Sadie claim.

On the Ladue group there are two main ore-shoots, one in the vicinity of each shaft. These shoots have lengths of about 150 and 500 feet, but practically terminate at the 400-level, very little ore having been found below that level. On the Sadie and Friendship group there are three shoots of ore. The smallest is 125 feet long, and the other two are 175 to 200 feet in length. As on the Ladue, very little ore has been encountered below the 400-level. The vein is cut by a fault which weaves along its length and is

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*Stockwell, C. H.: "Galena Hill, Mayo District, Yukon"; Geol. Surv., Canada, Sum. Rept. 1925, pt. A, pp. 1-15.

**Cockfield, W. E.: "Silver Lead Deposits of the Keno Hill Area, Mayo, Yukon"; Geol. Surv., Canada, Sum. Rept. 1920, pt. A, pp. 1-6, and "Geology and Ore Deposits of Keno Hill, Mayo District, Yukon"; Geol. Surv., Canada, Sum. Rept. 1923, pt. A, pp. 1-22.

accompanied by numerous cross fractures and small slips, and by one large cross fault on the Sadie claim. These faults have the effect of cutting the ore into a series of fault blocks, which adds considerably to the amount of development work necessary to expose the ore. These faults are much in evidence in the vicinity of the ore-shoots, and it is not known whether they had some influence on the deposition of the ore and continued as zones of weakness along which movement took place after ore deposition ceased, or whether the ore-bodies happened to be the weakest parts through which adjustments took place long after deposition ceased, thus causing a somewhat accidental relationship between the location of the ore-shoots and the post-mineral faults.

The vein continues as a strong fracture below the 400-level on these groups. It is mineralized with siderite, but is practically without ore minerals in that stretch in which development work has been carried out. There is, so far as is known, no adequate reason that can be assigned why mineralization should not continue to greater depths, nor has the existence of an unfavourable horizon for ore deposition been recognized. Possibly work elsewhere in the district will furnish the key to this problem, but in the meantime it may be stated that the known ore reserves of these two properties are approaching exhaustion and for the present at least their place will have to be taken by the other properties which the company is now developing to the stage of production.

The *Lucky Queen* property is situated on the western slope of Keno hill, somewhat less than a mile east of the Ladue. It is connected with the Ladue mill by an aerial tram, and there is also a road to the property from the main camp. The property consists of the Lucky Queen, Mud, Uncle Sam, and Mayo claims, the Too Good Fraction, and a lease on the Maythole claim.

There are in addition to the older workings described in earlier reports, two shafts, one to the 100-foot level, and the other to the 200-foot. These shafts are approximately 260 feet apart. From the main shaft levels have been driven southerly at 50, 100, and 200 feet, and work was in progress sinking the main shaft to the 300-level preparatory to drifting on that level. The 100-foot level has been driven approximately 1,300 feet in a southerly direction from the shaft. The 50-foot level terminates in an ore-shoot which has been removed from the 100-foot level to near the surface. This shoot was 80 feet long and varied from 6 to 10 feet in width; it included nearly all ore of shipping grade.

The vein follows a shear zone in quartzite and has a general strike of south 45 degrees west, astronomic, and a dip of 55 degrees to the southeast. It varies considerably in width, from seams to 10 feet, and in places the width is considerably increased by the presence of mineral in the joints and seams of the country rock. On the 100-level the ore zone is somewhat over 300 feet long, with some mineralization continuing beyond for a considerable distance to the south. On the 200-level, the ore zone had not been fully explored at the time of the writer's visit. On this level the mineralization in the seams and joints of the quartzites includes very considerable amounts of native and ruby silver, the former occurring as a coating on the galena.

It is to be expected, as development of this property proceeds, that other ore-shoots similar to the one already found will be discovered. Such ore-shoots rarely occur singly, and considerable further development is justified by the results already obtained.

Elsa Group. One of the holdings of the Treadwell Yukon Company on Galena hill is the Elsa group, consisting of the Elsa, Porcupine, Jean, Lucky Strike, Minerva, Minerva Jr., Keno, Mohawk, Punch, and Weston claims. This property lies on the northwestern slope of Galena hill, and is situated below timber-line in the vicinity of Porcupine gulch. The country rock in the vicinity is quartzite, with some graphite schist, and the mineralization occurs in a vein striking north 45 degrees east, and dipping about 55 to 60 degrees to the southeast. The vein varies considerably in thickness, ranging from a stringer to 6 or 7 feet. The ore minerals are galena and freibergite with some pyrite and chalcopyrite in a gangue of siderite and oxidation products. On the 200-level, the vein consists largely of oxidation products with small nodules of galena and freibergite. Judging by the silver content of this oxidized material, it is doubtful if there has been much movement of the silver by leaching. The thoroughness of the oxidation in this vein is probably accounted for by the fact that it contains considerable pyrite as contrasted with some of the other veins of the district.

Besides the original prospect workings there are three crosscut adits to the vein, either driven or in progress. The lower of these had not reached the vein at the time of the writer's visit, but was at that time about 800 feet long. The second level is 165 feet above the lowest level, and is 380 feet long to the point where it taps the vein, and from this point a drift has been driven to the south upwards of 500 feet with a raise to the surface, and a drift to the north is 240 feet long with a raise to the surface. At 140 feet in this drift the vein is cut off by a fault, and its northern continuation has not yet been located. The upper workings were filled with ice at the time of the writer's visit; they consist of a crosscut 200 feet long to the vein.

Arctic and Mastiff Property. This group was described at some length in Stockwell's report referred to above. Some of the earlier work was done by the original owners, and was continued by lessees. After this earlier work ceased the workings filled with water, and have only recently been drained by the new shaft put down by Treadwell Yukon Company, Limited. This shaft is being sunk in the country rock on the foot-wall side of the vein, to a depth of 200 feet, from which point a crosscut is to be driven to the vein. As at the time of visit sinking the shaft had not been completed, no new data regarding the property was obtainable from these workings. The older workings consist of a shaft about 85 feet deep, following the dip of the vein, with levels at 38, 70, and 80 feet. The workings on the south side of the shaft encountered a body of ore lying above the 70-foot level, and varying from 2 to 6 feet in width. This body has been stoped out to within 20 feet of the surface. On and below the 70-foot level the vein widens considerably, and shows disseminated ore minerals over a total width of about 70 feet. To the north of the shaft, the vein does not appear to be heavily mineralized.

The extension of the vein to the southwest has been stepped to the northwest by a fault, and has been traced on the surface by means of prospect shafts. The horizontal movement amounts to about 400 feet.

The minerals in the vein are galena, freibergite, and siderite, with some pyrite and quartz, and oxidation products such as cerussite, limonite, and manganese oxide. Taken as a whole the values are probably not as high as those obtaining on some of the other properties of the district; fairly massive galena assaying from 125 to 135 ounces of silver.

Silver King Group. This group is one of the most recent acquisitions of Treadwell Yukon Company, Limited. It is situated on Galena creek, to the west of Galena hill proper. This property was the first producer of silver-lead ore in Mayo district and its history dates back to about 1906, although it was not until 1912 or 1913 that it came into prominence. In 1914 it was acquired by T. Aitken and H. Munroe, who worked the property until 1916. In 1915 the property was reported on by Cairnes* who urged further prospecting on the extension of the vein. This, however, proved to be quite a difficult undertaking as in that direction the drift cover was thick, in some places attaining 70 feet, and after the property was closed down twelve years passed without any new discoveries being made. Last spring, however, the northern extension of the Silver King vein was picked up and an ore-shoot about 800 feet long, of which about half is reported to consist of shipping ore, was discovered on the Silver King and adjoining Webfoot claims.

The property was purchased last summer by Treadwell Yukon Company, Limited, and preliminary work, such as road building, erecting a camp, and shaft sinking, was started. As the original workings and the more recent prospecting shafts and cuts were inaccessible, being either sloughed or filled with water, an examination of the property was not made. It is expected, however, that this property will very soon enter once more into the list of producers.

The ore-shoots of the original properties worked by Treadwell Yukon Company, Limited, are approaching exhaustion after 7 years of continuous shipments, but the new properties now being brought in are fully capable of taking the place of the Sadie and Ladue groups, so that even if no further ore should be found on the older properties this does not mean that the company's operations in Mayo district will be discontinued, and should mining progress not be retarded by the unduly low prices obtaining for the metals produced, it might even be expected that the company's operations would produce a larger annual output than is the case at present.

As many as possible of the claims held by individuals were visited, but time did not permit of seeing even all those claims that have mineral showings on them, many of which have had considerable work done on them since the writer last visited the district. Claims were visited as opportunity occurred, but no ground lying to the east of Monument hill was included in the work of the past summer.

Shamrock Group. This group has been one of the most consistent producers of the claims held by individuals in the area. It lies near the head of Erickson gulch, adjoining the original holdings of Keno Hill, Limited, on the west, and is being worked under lease from the owners, by McIvor, McKay, and Formo. To date it has shipped 1,900 tons of sorted ore, of which amount 565 tons were shipped during the season of 1928-29.

The workings lie on what is believed to be one of the major veins, sometimes called the Gambler vein, which crosses Faro gulch and swings southwest across the broad flat at the summit above this gulch and consist of a shaft 120 feet deep and inclined at 60 degrees. This shaft has levels driven from it at depths of approximately 65 and 110 feet. The upper level

*Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1915, pp. 27-29.

is approximately 580 feet long, and drifts along the vein for about 250 feet to the south of the shaft to form an adit tunnel, and continues 330 feet to the north of the shaft. The lower level follows the vein for about 240 feet north from the shaft, and about 90 feet south. A number of streaks of ore have been encountered and stoped in these workings. As a general rule these have not been large, seldom exceeding 4 feet in width. Although the ore-shoots discovered to date have not been large, it is interesting to note that this property is one that has paid for its development by the ore extracted, and the chances seem very favourable that as development work goes on, other shoots of ore will be discovered.

Properties of Keno Hill, Limited. Very little work has been done on the original group of this company since the property was closed in the autumn of 1923. For several years after that the property was worked by lessees, and some ore, chiefly some that had been developed before, was extracted. The main workings were on the vein known as No. 9, with some prospecting on a number of other veins crossing the property. Lately the company has secured options on some of the adjoining claims, notably the Nabob, Toledo Fraction, Venus Fraction, Gold Hill, Orphan, and Ladue Fraction. On some of this ground one of the main veins has been traced in places by a number of open-cuts, and promising showings have been obtained at some points. Although many of the cuts have now sloughed, the dumps show galena mineralization.

Two of the other main veins, known as, respectively, the Kinman and No. 6 veins, cross the southern part of this company's property and have lately been receiving some attention. On the Kinman vein, representation work being done on the Porcupine claim near the head of Hope gulch encountered a shoot of ore 4 feet wide, which where exposed in the open-cut consisted of massive galena. Data with regard to the length of this shoot have not yet been obtained. The extension of this vein has also been discovered on the Teresa claim near the head of Charity gulch. This property is owned by Smith, Corp, and Ryan, and is leased to a group of individuals. The workings here consist of a shallow shaft, which at the time of the writer's visit had not quite reached bedrock, but which was yielding the float of the vein, making it apparent that the outcrop was not far off. This float was mineralized with quartz and arsenopyrite but contained none of the ore minerals.

Bunny Highlander and Cub Group. This group, owned by O. Letourneau and D. Mercure, adjoins the Lucky Queen on the northeast side. Six open-cuts have been excavated in which ore has been obtained, but in most of these, owing to sloughing, very little information with regard to the deposits could be obtained. To the northeast of these is a shaft 26 feet deep terminating in a drift 48 feet long. These workings were filled with water, and, therefore, were inaccessible. It is reported that 51 tons of ore was obtained from these workings, and that the ore-body on the floor of the drift showed 2 feet of massive galena. From the material on the dump it is evident that the ore-body consisted of a shear zone in quartzite, with siderite, pyrite, galena, freibergite, and zinc blende. Much more work is necessary on this property before the exact relations of the various showings can be determined. It is possible that the mineral showings represent the faulted, northward extension of the Lucky Queen mineralization, but until more work is done, it is impossible to prove this is the case.

Stone Group. This property is owned largely by M. Butyer who owns outright the Stone and Ray claims, and has a half interest in the Scott claim, the other half interest being owned by Mrs. W. C. Sime. The property is situated northeast of the ground last described, and extends across Faro gulch. The main workings are on the slope on the western side of Faro gulch, and consist of two adits. A third was, at the time of the writer's visit, being driven lower down towards the creek, but had not yet penetrated the overburden. The lower of the two completed adits is about 475 feet long, with a crosscut, 16 feet long, to the east at 230 feet, a crosscut 70 feet long to the west at 430 feet, and several small stopes at intervals in the adit. At the face there is a fault with a highly polished hanging-wall with 18 inches of siderite and freibergite. The balance of the face shows shattered greenstone with siderite. About 15 feet back from the face there is about 1 foot of siderite heavily impregnated with grey copper, in which a small stope about 12 feet high and about the same length has been excavated. The 70-foot crosscut to the west is in schist which has been shattered and filled with siderite, and carries some values throughout. This terminates against a greenstone body, into which the main adit penetrates about halfway between the crosscut and the face. The shorter crosscut shows the orebody to be about 12 feet wide.

The upper adit is 135 feet long, and is now partly caved near the entrance. It encounters the vein about 30 feet from the portal, and continues along the vein for the balance of its length.

A shipment of 6 tons from this property assayed 161 ounces of silver to the ton, and a small shipment, less than a ton, of hand-sorted ore showed 586 ounces of silver to the ton.

Apex Claim. This property is on the southern slope of Keno hill, on the southwest side of Charity gulch, and is owned by T. McKay, and worked under option by F. Hoffman and J. Grenier.

The development work includes an open-cut terminating in an adit with a winze sunk near the face. The general course of the vein is north 45 degrees east, and it is composed mainly of manganese oxide and siderite. Most of the workings do not permit of obtaining an idea of the mineralization owing to the timbering that was necessary in the adit. At 35 feet the adit encountered a slip striking north 77 degrees east, and dipping to the northwest on which a winze was sunk 18 feet. This slip was mineralized with calcite and zinc blende. The workings to date have not encountered any ore-shoots of value.

Vanguard Claim. This claim adjoins the Apex on the south and is being worked by D. Ferguson and associates. A considerable amount of heavy galena float was picked up on and near the surface and a good deal of prospecting work has been done in an endeavour to locate the vein from which the float came. From the nature of the float it is deemed impossible for it to have travelled any great distance, and although the present workings have not yet picked up the vein, further prospecting in the vicinity is justified.

Bunker Hill. Only one property was visited on Bunker hill, namely the Homestake group, which consists of six claims owned by J. Walsh and associates, and leased by J. Carpenter, J. McLean, and G. Lee.

The work done consists of two open-cuts, and a shaft 43 feet deep with a drift 15 feet long in a southerly direction from the bottom of the shaft. The shaft at the time of the writer's visit was filled with water to within 6 feet of the surface, so that very little of the vein could be seen. The strike of the vein is approximately north 30 degrees east astronomic, and the dip 70 degrees to the southeast. It is reported that at the bottom of the shaft the vein had a width of 7 feet; composed of a little over 3 feet of siderite, and somewhat over 2 feet of shattered quartzite with siderite, followed by 1 foot of siderite with streaks of the ore minerals through it. South in the drift the vein narrowed to 5 feet, and was about half siderite and half country rock; towards the end of the drift the siderite appeared to pinch out. The siderite is coarsely crystalline with blebs and streaks of galena and grey copper in it. To the north of the shaft a width of 4 feet of siderite was encountered in an open-cut, and still farther to the north a second open-cut, which had not reached bedrock, showed heavy siderite float. Further surface prospecting is desirable on this property, before underground work is undertaken, but prospecting is difficult, as the overburden is about 12 feet thick.

Sourdough Hill

A number of promising showings have been located on Sourdough hill, which lies immediately to the south of Keno hill, and a considerable amount of work has been done on these in the past few years. Unfortunately, however, the ownership of this ground has been the subject of litigation, and in the meantime the work has not been proceeded with. Such workings as exist are full of water and, therefore, inaccessible.

Galena Hill

A number of mineral showings have been found on the northern and eastern slopes of Galena hill. Time did not permit of visiting all of these, and on many of those visited earlier work had sloughed so that little could be learned. Many of the properties are described in Stockwell's report referred to before.

Hector and Darling Claims. This property is owned by C. Sinyard and M. S. McCown, and is situated just west of the summit of the hill. A vein striking from north to north 20 degrees east and dipping from 45 degrees east to vertical has been prospected by means of a number of pits, and several prospect shafts. The main shaft is 57 feet deep with a drift 82 feet in all at the bottom and extending both to the north and south from the bottom of the shaft. The vein in the shaft shows about 5 feet of oxidized material with nodules of galena. To the north of the shaft in the drift, the vein is about 8 feet wide, with bunches of galena and carbonates throughout. It is reported that this material will assay from 60 to 70 ounces across the width of the vein, and that samples of the clean galena yield very high assay values. Two other prospect shafts, one about 50 feet north of the main shaft, and the other about the same distance south, have picked up the vein. On the Darling claim to the south, a number of open-cuts and prospecting ditches have been put in, but these have not yet been successful in picking up the extension of the vein.

Eagle Group. This group is owned by A. McLeod, M. S. McCown, D. Matheson, and Miss J. Stewart, and is situated near timber-line on the easterly slope of Galena Hill. A vein which strikes north 40 to 50 degrees east and dips about 67 degrees to the southeast has been located by means of a number of open-cuts and by sluicing. The vein was not very well exposed at the time of the writer's visit, but is apparently about 18 inches wide, and mineralized chiefly with quartz and arsenopyrite, with seams of galena. From the float visible on the dumps it is apparent that siderite, pyrite, limonite, and sphalerite also occur.

Rio Claim. On the Rio claim, owned by Mrs. W. C. Sime, a vein is exposed by an incline driven down the strike of the vein. The incline is about 30 feet deep, and follows a stringer of galena which widens to 3 feet. The vein strikes north 37 degrees east and dips at 63 degrees to the southeast. Immediately below the large showing the incline is filled with water. Some 65 feet lower in elevation an adit was started with the intention of striking the vein, in which all told 140 feet of drifting and crosscutting was done, but the workings were not driven sufficiently far to intersect the vein.

Bluebird Claim. This claim is owned by O'Sullivan and Nicholson. On it a vein striking north 27 degrees east and dipping 62 degrees southeast was exposed by means of open-cuts. The vein is mineralized with galena, sphalerite, and pyrite, in a gangue of ankerite, calcite, quartz, limonite, and manganese oxide. Two shafts have been sunk, the lower of which is 40 feet deep, and hit the vein at 22 feet. The upper shaft is 23 feet deep. Both shafts were filled with water at the time of the writer's visit.

Tin Can Claim. This claim is owned by A. McLeod, H. Rohr, and S. Turpin, and is situated on the eastern slope of Galena hill. Most of the workings were full of water or ice, so that very little information could be obtained with respect to the mineralization. One shallow pit, the highest of the group of workings, showed, in greenstone, a small vein striking north 40 degrees east and dipping 82 degrees to the southeast. The maximum width of mineralization exposed in this pit is about 12 inches. The vein is heavily oxidized and carries abundant zinc.

Formo Group. A group of seven claims on the northern slope of Galena hill, near the mouth of Christal creek, is owned by H. C. Formo. The workings consist of a shaft about 30 feet deep. It was partly filled with water. The vein strikes nearly north and south, and for the first 16 feet in the shaft is nearly vertical; below it flattens out to an angle of 45 degrees, and towards the bottom of the shaft is reported to be straightening up again. The vein is about 3 feet wide. On the foot-wall side there is a seam of calcite 4 inches wide, followed by slightly over $2\frac{1}{2}$ feet of galena, with zinc blende and pyrite. The wall-rock is greenstone. It is reported that fairly pure galena carries about 120 to 135 ounces of silver to the ton, a somewhat lower silver value than obtains in most of the surrounding properties.

Beaver River Area

Time did not permit of making a trip to Beaver River area. The Consolidated Mining and Smelting Company, Limited, has for several years been developing a prospect on McKay hill in this area, and surface work resulted in a very good showing of ore. During the summer of 1929 the property was diamond drilled, and it reported that the results were very disappointing, as it was found that the deposit did not extend to any reasonable depth. It is reported that the option held by this company has been abandoned.

Windy Arm District

Last year a group of claims known as the Dail and Fleming group situated along the west side of Windy Arm near the boundary between Yukon and British Columbia, attracted some attention. A company known as Yukon Gold Mines, Limited, incorporated under the laws of British Columbia, was formed to take over these claims, and to develop them. Early last spring a start was made on the development of the property.

The company owns the Humper, Red Deer, Peggy, Bull Moose, Venus Extension, and Ray claims, and has options on the Humper No. 2, Nipper No. 2, Hobo, Lakeshore, Bum, Ruby Silver, and Maybell Fraction. This property and the adjoining property, the Venus, have been described at length by Cairnes* and that description has been summarized by the writer**, so that only a brief description need be given in this connexion.

Unfortunately for the enterprise, operations were started before sufficient money was in the treasury to carry the project through to a successful conclusion. Difficulties of financing arose after development work had started, and the operations had to be abandoned without thoroughly testing the ground.

The rocks of the area are Mesozoic andesites with their accompanying tuffs. The claims are at no great distance from the main contact of the Coast Range batholith, and some intrusives, apparently related to the batholith, also occur in the area between Windy Arm and lake Bennett. The veins are fissures filled mainly with quartz, arsenopyrite, and galena, with some zinc blende. A number of other minerals are present, but are by no means abundant. These include a number of silver minerals such as argentite, pyrargyrite, stephanite, and some native silver; also jamesonite, yukonite, chalcopyrite, and chalcocite, and the arsenic minerals orpiment and realgar, together with oxidation products of copper and lead. The ores are valuable chiefly for their gold and silver content.

There are three main veins. Some other showings occur, but the work done on them is not sufficient to enable a true idea of their importance being obtained. The vein to which attention has been mainly directed is known as the Venus vein. This is apparently continuous across the Venus property, and extends into the property of Yukon Gold Mines, Limited, on the Venus Extension claim. It has not been traced across the Venus Extension claim. Certain workings on Nipper No. 2 have exposed a vein in a gulch to the south of the Venus Extension. This vein may possibly be the continuation of the Venus vein, but more work is necessary in order to prove this. The Venus vein strikes approximately north 10 degrees east astronomic, and varies considerably in its dip, ranging from nearly flat to 60 degrees. In most places, however, the dip is about 30 degrees. The thickness of the vein ranges from a few inches to 6 or 7 feet, but is generally from $2\frac{1}{2}$ to 3 feet on the Venus claim and from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet on the Venus Extension. The workings include an incline shaft reported to be 140 feet deep, but which at the time of the writer's visit was filled with water below 115 feet. Near the bottom of the incline drifts run north and south along the vein; higher in the incline, an intermediate drift runs north. About 800 feet southerly from the incline, and about 75 feet below it in elevation, is an adit which drifts along the vein for 560 feet, and which has several raises one of which extends to the surface. Near the southern boundary of the Venus Extension, another adit, known as the Dail tunnel, drifts along a small vein for about 26 feet.

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*Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1916, pp. 39-44.

**Cockfield, W. E., and Bell, A. H.: "Whitehorse District"; Geol. Surv., Canada, Mem. 150, pp. 40-41 (1926).

On Nipper No. 2 there are two crosscut tunnels, the lower 170 feet long, with a drift to the south in a fault zone, and the upper 90 feet long. Both were, apparently, driven to explore a vein showing in the gulch higher up, but neither is long enough to reach its objective. The vein on the surface is partly exposed by a number of open-cuts. It has a strike of north 30 degrees east, and a dip of 30 degrees into the hill. The mineralization is very like that of the Venus and Venus Extension vein. The thickness of the vein where exposed in the gulch is about 12 inches. As pointed out before, there is a possibility that this represents the southerly extension of the Venus vein, but more work is necessary in order to prove this.

On the Red Deer claim a vein is exposed in three small open-cuts. Where exposed the vein has a thickness of about 2½ feet, and is mineralized with quartz, pyrite, and galena. The mineralization at these points is somewhat scanty, but it appears fairly well-established that the best of the ore at these points was removed when making the open-cuts. The vein strikes north 30 degrees east astronomic, and dips to the northwest at about 50 degrees. At these localities Cairnes specifically mentions a number of high-grade silver minerals, but none is now visible.

On the Humper claim, the Humper vein is exposed by a shallow shaft and a number of open-cuts. The same vein is exposed in another shaft on Humper No. 2. The strike of the vein varies from north 60 degrees east to nearly east astronomic, and the dip ranges from 35 to 65 degrees to the north. The entrances to the shafts are caved so that nothing can now be learned from these workings. The gangue of the vein is quartz, with galena and pyrite as the chief ore minerals present. High-grade silver minerals were also reported by Cairnes from these workings, but none was identified by the writer.

There are a few other points on the Yukon Gold Mines property where mineral showings have been found, but on these not sufficient work has been done to give a true idea of their relations and importance, though some of them are probably deserving of further work.

The Venus property is not part of the holdings of Yukon Gold Mines, Limited. No work has been done on it for a number of years, and as the later winzes are nearly filled with water, there is nothing to be added to the earlier reports on this property, to which the reader is referred for full details.

The Venus vein which crosses the Venus and part of the holdings of Yukon Gold Mines, Limited, has been established to be continuous. It crosses Venus No. 1 and No. 2, and part of Extension claim, thus giving it a length as traced on the surface, of between 3,500 and 4,000 feet. The vein averages perhaps 2½ to 3 feet in width, and the metal values are not high. The vein on the Venus has been proved to a depth of about 630 feet below the surface, but of its characters in the lower workings there is not a great deal of information available. It is difficult, without a systematic sampling of the properties, to estimate the average content of the ores, as the values appear to be somewhat erratic. Some high assays have been obtained from the veins in this section, but Cairnes concluded, from a survey of different samplings made from the properties, and from smelter returns, that the ore in general would run under $25 in gold, and from 5 to 10 ounces in silver to the ton, and that the average content might possibly be about $15 a ton, based on normal prices for silver. Much of the vein is, of course, very low grade, and will not go over $10 a ton. It is difficult at the present time to secure representative samples from the Venus workings, as the best of the ore has undoubtedly been extracted from the workings open to inspection. The writer took a number of samples which are intended not as a systematic sampling of the property but rather to afford a general idea of the mineral content. The assay results of these samples are listed below.

No.	Location	Gold	Silver	Lead	Zinc
		Ozs. per ton		Per cent	
1	Extension adit	0.41	0.73	none	none
2	"	0.41	1.54	0.50	none
3	"	0.25	4.01	1.37	none
4	"	0.17	1.82	0.65	none
5	"	0.30	9.45	3.54	none
6	"	0.19	3.97	0.66	none
7	"	0.05	25.36	0.51	none
8	Raise from adit	0.29	0.82	0.09	none
9	Extension shaft	1.64	8.11	2.67	none
10	"	0.29	3.04	0.79	none
11	"	0.44	3.01	0.73	none
12	"	0.76	40.35	7.34	0.61
13	Dail tunnel	0.06	0.46	0.14	none
14	Nipper	0.05	6.07	1.87	none
15	"	0.02	1.57	0.33	none
16	Venus N. adit	0.14	22.61	7.34	0.61
17	"	0.06	2.71	0.56	0.59
18	"	0.06	6.34	1.77	5.12
19	"	0.02	2.09	0.72	0.40

There is no ore blocked out on the properties, but a considerable tonnage of ore is indicated by the present workings. The Humper and Red Deer veins are worthy of investigation to test their continuity and mineral content. Although the tenor of the ores is undoubtedly low, it seems probable that with careful, systematic sampling, ore-shoots of economic size and value could be outlined, and there seems a chance that with economical management the properties might develop into a small mine.

1930

Introductory Note

The following note, by G. A. Young, Chief Geologist, appears in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1931, page 13, and relates to field work in 1930 in Yukon Territory:

"W. E. Cockfield reviewed mining developments and further investigated geological problems in Dawson, Mayo, and Whitehorse mineral areas. This was done in accordance with the plan, inaugurated last year, of presenting an annual review of mineral developments in Yukon. The review will appear in Summary Report 1930, Part A, and has been supplied, in advance of publication, to the Department of the Interior, which is charged with the administration of Yukon Territory.

"E. J. Lees, under supervision of W. E. Cockfield, continued topographical and geological mapping of Laberge quadrangle (latitudes 61° to 62°, longitudes 134° to 136°), southern Yukon. This area lies along the eastern margin of the Coast Range batholith and, therefore, is geologically favourable for the occurrence of metalliferous deposits."

THE MINING INDUSTRY IN YUKON, 1930

by W. E. Cockfield

About half of the field season of 1930 was devoted to visiting some of the mining camps in Yukon and northern British Columbia.

The year 1930 was a difficult one for the mining industry of the north as early in the year the decline in metal prices made it apparent that some of the enterprises could be carried on only with great difficulty. This decline, owing to the remoteness of the main producing camp in Yukon and to the fact that ore shipped during any season is largely hauled to the river before the spring break-up, is not reflected in the shipments for 1930. The Mayo camp shipped 10,000 tons of ore and concentrates and, although accurate figures are not available, this may be estimated to contain roughly 5,000,000 ounces of silver and 5,000 tons of lead. These figures constitute a record for the camp.

Actual figures for the production of placer gold are not available and estimates from different sources show considerable differences. The production may show a slight falling off as compared with 1929, but as all estimates were made prior to the close of the season they are subject to correction according to the amount of gold recovered by operations in the autumn.

Placer Mining

In Klondike district, Yukon Consolidated Gold Company had four dredges in operation. Two of these were boats of the larger type and were worked on the Klondike flats between the mouths of Bonanza and Hunker creeks. The other two were working on Dominion creek, one at Cariboo and the other near Granville. In addition the company operated its hydraulic plants at Jackson gulch on Klondike river, and at Lovett gulch on Bonanza creek. It is reported that the hydraulics did not operate to capacity owing to lack of rainfall and also owing to the interruptions caused by breaks in the ditch.

A number of individuals are, also, working claims in Klondike district. These account for about eight properties being worked on Hunker creek and its tributaries and approximately the same number on Bonanza creek. On the Dominion slope there are six properties being worked on Quartz creek, three on Sulphur, one on Gold-run, and several on Upper Dominion creek. It is estimated that the production will not exceed $50,000.

In Sixtymile area a dredge which was put into operation in 1929 is at work on the concession between the mouths of Big Gold and Miller creeks. No data are at hand with regard to the success of this operation. It is reported that on Thistle creek the operations carried on by Manley have been closed down. A small amount of work is being carried out on numerous other creeks in the territory.

Towards the close of the season a strike was made on Lake creek which enters Big Salmon river 2 miles below Livingstone creek and this strike has revived interest in a district long neglected. The discoverer, Mr. T. Kerruish, reports finding what appears to be a preglacial channel, on the right limit of the creek. The gravel contained in this is reported to be fine compared with the heavy wash in the bed of the creek. The paystreak has a width of 40 feet, with a depth to bedrock of 12 feet, but as the discovery was made late in the season, its linear extent is not known. The grade of the creek is steep; water is not abundant, but there is a sufficient supply to permit of sluicing for some hours each day. The gold obtained is high in value, assaying $18.50 an ounce; and is prevailingly coarse, by far the larger amount consisting of nuggets. There is no fine gold. The gold brought in to the bank yielded $2,360; Mr. Kerruish estimates that this was recovered from 546 cubic yards of the paystreak. An additional 50 ounces had been obtained, but not delivered at the bank at the close of navigation. The gold is believed to be scattered through the paystreak and not confined to within a short distance from bedrock. A placer lease of a mile has been staked on the creek, and 600 feet of pipe and a 4-inch monitor installed. It is probable that this discovery will stimulate more interest in Salmon area and that considerable prospecting will be carried out there this winter and next summer.

Lode Mining

Mayo District

Mayo district has furnished the only production from lode mining during the year. As already pointed out, the decline in metal prices did not cause a reduction in shipments during 1930. Present plans, however, call for a drastic reduction in tonnage to be shipped in 1931; these plans call for a shipment of 4,000 tons. The reduction in silver output will not, however, be as great as indicated by the tonnage figures, for the concentrates to be shipped in 1931 will be much higher in silver than those shipped in 1930, and but little crude ore will be shipped. Recent advices from Mayo are to the effect that the tonnage may be increased to 6,000; but of this there is no confirmation.

The decline in silver prices has undoubtedly brought about a large reduction in ore reserves. An ore that was profitable a year ago can no longer be considered as ore; the minimum content of silver necessary for profitable operations has nearly doubled. Consequently, material that falls under the minimum for profitable operations must be left in place, and will not likely become available during the lives of the enterprises unless silver speedily reverses its recent price trend. The type of ore must also be carefully scrutinized. An ore may contain the minimum of silver necessary for profitable mining, but if the silver cannot be concentrated to the point where shipping is profitable, the ore cannot be mined at a profit. The ratio of ounces of silver to unit of lead thus becomes of extreme importance. In the early days of the camp an ore with 200 ounces of silver and 60 per cent lead was shipped without concentration. Such an ore or concentrate is no longer profitable. The reduction in ore reserves brought about by these considerations has been quite severe. Although definite statements of the tonnages of ore in sight are not available for the full time the camp has been working, it may be stated that in 1929 the ore in sight was very nearly as great as at any time during the development of the camp. At the close of 1930 Treadwell Yukon Company, Limited, announced that the ore in sight in its properties was sufficient to last two and a half years.

The individual operator is the hardest hit. In most cases he cannot produce at all and is forced either to close down or to content himself with development work or with merely doing the necessary assessment work to hold his ground in good standing. Some few individuals are fortunate enough to possess small bodies of ore that can be hand-sorted for shipment even at present prices, but on the whole the production from these sources will be very small. The company, on the other hand, can by concentration raise its ores to the point where shipping becomes profitable.

Along with the decline in silver prices there has been a slowing down of development. In 1929, Treadwell Yukon Company, Limited, had four properties under option with development work proceeding on these and prospects seemed bright for a second mill in the camp. It seems likely that the course to be followed will be to exhaust the ore in the property now being mined and then to move the present mill to a point where it can serve the other properties.

With regard to the ore deposits themselves, certain facts stand out from the developments that have taken place in the past few years and these have considerable bearing on the future development of the camp. In the first place, the ore-shoots that have been developed do not extend to any great depths. The Sadie ore-shoot proved to be the largest found to date and furnished 110,000 tons of ore. It did not extend below the fourth level, 400 feet from the surface, and the same has proved to be the general rule for the ore-shoots of the camp, which have been fully developed. In some cases the veins continue downward almost undiminished in size, with a siderite gangue, but ore has not been found to a depth of more than 600 feet in any deposit. However, on only one deposit, namely, the Ladue where considerable drifting was done on the 6th level, has development taken place at this depth.

It may be that ore deposition in any one vein was for some reason confined within very sharply defined vertical limits, or it may be that ore-shoots do occur at different elevations within the same veins. If the first view be accepted and if ore deposition was due to a temperature gradient, it would have to be assumed that the present surface is essentially the same as though deeper than the surface at the time of ore deposition, for ore-shoots outcrop at many different elevations on the hill and there is no evidence that ore-shoots on the top of the hill extend deeper than those found at lower elevations. The view that the ore-shoots are prevailingly shallow has much to support it, as five of the more promising deposits have been bottomed at relatively shallow depths. On the other hand, the second view, namely, that other deeper ore-shoots may occur in the same veins cannot be said to have been disproved, particularly in those cases where the veins are known to continue below the known ore-shoots.

A second feature which stands out is the existence of a number of northwesterly trending faults. The prevailing trend of the mineral veins is northeast. The northwest faults cut and offset them and in some cases the connexion between the northwest faults and the positions of ore-shoots is striking. The view may be held that the northwest faults are post-mineral and that their apparent connexion with the ore-shoots is accidental, or, at most, brought about by such shoots being located in weaker parts of the strata through which such faults would naturally trend. On the other hand, the faults may be regarded as being pre-mineral fissures at whose intersections with the northeast fissures ore deposition took place, movement continuing along the faults after the conclusion of ore deposition. If this had been the case, the faults would, possibly, have been the main circulating channels and have given rise to the ore-shoots in the northeast fissures, thus accounting for the localization of ore-shoots near the northwest faults. Against this explanation may be urged the lack of mineralization in the northwest faults. So far as known they do not contain ore other than that which might be considered as having been dragged into the fault zones. Whatever view is accepted, the occurrence of ore-shoots at or near the intersections of the two types of fissures is striking and though there are probably not enough examples to prove that as a general rule they are so localized, yet the available evidence supports such a rule which is important as possibly limiting the areas that must be intensively prospected. Unfortunately, owing to overburden, the courses of the faults cannot be traced for considerable distances and, in many cases, their presence can only be inferred from the offsetting of one part of a vein with respect to another.

Company Operations

Treadwell Yukon Company, Limited, had in 1929 four properties under option or purchased and was developing these in addition to mining the Sadie property. The ore on the Sadie, which was worked under lease from Keno Hill, Limited, was exhausted early in 1930 and the Sadie and the adjoining Ladue property, owned by Treadwell Yukon Company, Limited, were closed down and mining operations transferred to the Lucky Queen situated about a mile from Ladue camp.

Lucky Queen Group. The shaft on this property has been sunk a short distance below 300 feet and drifts have been run on the 50, 100, 200, and 300-foot levels. All these drifts are to the southwest of the shaft and are 300, 1,300, 1,100, and 650 feet long. A number of crosscuts and subsidiary drifts run on different levels explore the ore-body thoroughly. There are two main ore-shoots, the first being 170 feet long on the 100-foot level and 280 feet long on the 200-foot level. The second is about 240 feet long. The width of the ore varies considerably from point to point. The mineralization is freibergite, galena, and zinc blende in a siderite gangue. Ruby silver and native silver are somewhat common on and below the 200-foot level and oxidized ore is common from the 100-foot level up. The ore-shoots have not been fully explored on the 300-foot level. Two main faults cut the ore-bodies, one of which has been tentatively correlated with a similar fault in the Sadie workings. The Treadwell Yukon interim report, published at the close of 1930, gives the ore reserves in the Lucky Queen as sufficient to last about a year. There is still the chance of finding more ore in this property as mining progresses.

The Company's option on the Arctic and Mastiff group on Galena hill has been abandoned. The company put down a 200-foot shaft in the foot-wall of the vein and crosscut to the vein at the 200-foot level. A second shaft was put down on a faulted segment of the vein lying southwest of the main workings. This is reported to be 50 feet deep. These workings were full of water and consequently could not be examined. Since the option was abandoned the owners have found another faulted segment of the vein to the northeast of the main workings.

Breifalt Property. Development work on this property was partly completed and the property closed to await the moving of the mill from the Ladue property. This property is developed by three crosscut tunnels at elevations of 3,320, 3,240, and 3,070 feet. The highest of these is 210 feet long; the intermediate is 380 feet with a drift to the northeast of 130 feet and a drift to the southwest of 1,100 feet. The lower adit is 1,020 feet long and hits a small stringer at 660 feet and a quartz vein at 980 feet. This vein has a reverse dip to that of the main vein and lies on a greenstone contact. It varies in width from 1 foot to 2 feet. It joins the main vein 90 feet from the adit. Drifts have been run from the adit 440 feet to the southwest and 520 feet to the northeast with a crosscut 160 feet long situated 320 feet from the adit along this drift.

The northeast drift of the intermediate level terminates in a fault zone and the vein has not been picked up beyond. Some development work remains to be done on this property to the northeast of the fault zone, and also to find the course of the ore between the intermediate and lower levels. Otherwise the tonnage available is known with a fair degree of certainty.

Silver King Property. This property was the first producer of silver-lead ore in Mayo district. After working out a single shoot of ore the owners closed the property and although numerous attempts were made to trace the vein and to locate other ore-shoots, it was not until 1929 that the continuation of the vein to the northeast was found and a promising shoot of ore located on this and the adjoining claim, the Webfoot. Both properties were optioned to the Treadwell Yukon Company, Limited. Development and the erection of a camp were started in 1929. A shaft has been sunk to 200 feet and levels driven at 100 feet and 200 feet. At the time of the writer's visit the south drift on the 200-foot level had been driven 120 feet. The width of the ore was 5 feet and it was very high in zinc. On the 100-foot level the north drift was 100 feet long and above it the material has been largely stoped out. The south drift on this level is 420 feet long with the material above largely stoped out. The maximum width of the vein is 8 feet and the mineralization is galena, zinc blende, and freibergite in a siderite gangue. Ruby silver is plentiful in the upper workings.

Keno Hill, Limited. This company recently started development on an ore discovery made on the Porcupine claim in the course of assessment work in 1929. It is the intention of the company to sink a prospect shaft on this showing and to drift from the bottom of the shaft should the results obtained be favourable.

The company has abandoned the option which it held on the Nabob claim and several others in the vicinity of its original group.

Reserve Mining Company. The property of this company has lain idle throughout the year.

Nabob Claim. The owner, L. Beauvette, has put in several open-cuts, tracing one of the main northeast veins of the vicinity from the holdings of Keno Hill, Limited, part way across this claim. These cuts are close to the shaft which had been sunk on this vein and some ore of milling grade has been found in them. The vein has also been traced farther to the east by a series of cuts, but no new development has been added to this group of workings during the year.

Stone Claim. The owner, Mat Butyer, is engaged in driving a long tunnel to cut, at a lower elevation, the vein found in the older workings. This tunnel is now 240 feet long and is still in overburden. About 100 feet from the portal the tunnel passed through a reef of schist, but after passing this once more entered gravel. The gravel contains boulders of ore material such as siderite with galena and grey copper, and also pyrite and chalcopyrite. The pyritic material carries high gold values. The gravel in which this material was found is quite evidently of glacial origin as it carries pebbles and boulders of granite, a rock which does not outcrop on Keno hill. Consequently the finding of the ore material in it cannot be looked upon as indicating with any certainty the occurrence of veins close at hand. This tunnel is 460 feet below and 1,400 feet distant from the older workings.

Shamrock Group. Work at this property had been suspended at the time of the writer's visit. It is reported that the lessees of this group shipped 500 tons of ore in 1930, but that no attempt will be made to ship ore during 1931.

Silver Basin Group. This property is owned by R. Rasmusen and occupies part of the steep northeasterly slope of Silver Basin gulch. A large amount of work has been done on the property at different times, but the entrances to nearly all the adits have caved, thus making an examination unsatisfactory as it is difficult to secure the relations of one showing to another. The property is one on which it is difficult to keep the various cuts and adits open owing to the heavy overburden and steepness of the slope. Some of the mineral showings may still be observed in the open pits. It would appear that there are two main veins cutting diagonally across the steep slope and that there are a number of cross fractures in connexion with these, some of which carry mineralization. The lower vein where exposed has a width varying from 2 to 7 feet and strikes north 77 degrees east with a dip of 70 degrees to the southeast. The upper vein is approximately 4 feet wide. Both are quartz-arsenopyrite veins carrying galena, freibergite, and zinc blende in places. Gold values of $10.50 a ton are reported from a shipment of 12 tons.

Some of the cross veins carry mineralization, but details with regard to them cannot be supplied.

Dorothy Claim. This property is being worked by E. Corp and J. Ryan. A siderite vein 4 feet wide has been traced for nearly 200 feet on the surface by means of two shafts and an open-cut. One shaft is 55 feet deep and is terminated by a drift 35 feet long to the southwest. The second shaft is 45 feet to the northeast of the first. Both were filled with water. Several open-cuts beyond these workings have not picked up the vein. No ore minerals were encountered in the workings other than a few specks of grey copper. One block of galena was encountered on the surface near the outcrop. The vein is probably cut off to the northeast by a fault, but there are so few exposures that this could not be definitely determined.

No Cash Claim. This claim is owned by Breifalt and Tolmie and worked under lease by E. Bjonnes. There is a shaft 50 feet deep with two drifts, one slightly higher than the other, at the bottom. These drifts are connected by cross-cuts. One drift is on the foot-wall and the other on the hanging-wall side of the vein. The hanging-wall drift is 60 feet long, it extends 15 feet to the north and 45 feet to the south of the shaft. The foot-wall drift is 22 feet long on either side of the shaft. The hanging-wall of the vein shows a dip of 55 degrees and the foot-wall varies from 60 to 75 degrees. Between the two drifts there is a streak of low-grade ore. The ore on the hanging-wall is 5 feet wide and is fairly high grade; the lean ore between the two drifts is $3\frac{1}{2}$ feet wide; and the foot-wall streak is well mineralized and about 3 feet wide. Very high assays have been secured from the ore as hand-sorted for shipment. The lessee shipped 21 tons during 1930, but the actual returns for this were not available. Mr. Bjonnes states that a channel sample cut across the whole width of the deposit assayed 75 ounces.

Tyee Claim. This claim is owned by H. E. Formo who has also an option on the adjoining claim, the Rocket. These claims are situated on the northern slope of Galena hill near the mouth of Christal creek. A considerable amount of work has been done improving the trail to the property. The workings consist of an incline shaft 80 feet deep; the dip of the vein is somewhat flatter than normal, being about 35 degrees, and the strike is north 17 degrees east. There is a drift to the south at the bottom of the shaft and another drift to the south at 60 feet with a raise connecting the two. Both these drifts are 15 feet long. At the bottom of the shaft there is a 15-foot drift to the north. The ore is 20 to 28 inches wide in a vein which shows a maximum width of 4 feet in the shaft. In the bottom of the shaft the ore increases to 36 inches, but is of much lower grade, containing much pyrite and zinc blende. In the north drift the vein is cut off by a northwesterly trending fault and no attempt has been made to pick it up beyond this fault. The best ore was found 25 to 30 feet down in the shaft and 40 tons of this were sorted and shipped. The smelter returns on this shipment were not available, but assays of the ore made before shipment indicated a content of between 225 and 250 ounces of silver and 60 per cent lead.

Bunker Hill

Homestake Group. Only one property was visited on Bunker hill, which lies to the south of Keno hill. This property, the Homestake group, is operated under lease by J. Carpenter and J. McLean. The workings consist of two shafts close to one another, a crosscut and a number of open-cuts. Owing to sloughing the vein cannot be seen in the open-cuts or crosscut and the shafts are full of water. The original shaft is reported to be 32 feet deep and the second shaft 42 feet deep with a drift 15 feet to the south and a drift of 7 feet to the north. Three hundred and fifty feet to the north of the shafts, the vein was reported to have been found in an open-cut, but this cut was also sloughed and consequently the showing could not be examined. A streak of galena $2\frac{1}{2}$ feet wide was reported as occurring in the second shaft.

Klondike District

Lone Star Property. A hurried visit was paid to the Lone Star property near Dawson. As this has already been described* there is no need to repeat the details with regard to the property. The object of the work being done at present was to crosscut the mineral zone and then drift along it to a point below a shaft sunk some years ago and connect with the shaft by means of a raise, thus draining some of the older workings. The crosscut was driven 196 feet and from the point where it intersected the mineral zone a drift was started towards the shaft. Considerable quartz with pyrite and galena, also specimens of free gold, were encountered in the drift.

A survey of the data obtainable with regard to this deposit shows them to be contradictory. Assays from channel samples have shown almost uniformly low results and with the exception of occasional high assays, are, if these results are to be accepted, sufficient to condemn the property. On the other hand the management has assayed numerous grab samples, most of which show good values. The tendency would be to discard the results of these assays were it not for the fact that mill tests have shown a rather uniform recovery of $3 a ton, or slightly better. The management states that approximately 8,000 tons of rock from the open-cut was milled and the gold recovered was approximately $24,000. At that time, it is claimed, the mill was not equipped to recover the values contained in the sulphides and it was felt that the loss on this account was high. Consequently, 1,860 pounds of hand-sorted ore was shipped to a smelter and the return from this shipment was $2,200. These statements are given added weight by the publication of certain of the mill tests by MacLean who sampled the property. The mill tests for 1912 as summarized by MacLean are as follows:

Ore milled	Recovery	Average
2,495 tons.	$9,467.58	$3.79 per ton

The workings from which this ore came were sampled at the time the mill tests were being run and the weighted average of the samples is only 77 cents a ton. It is not to be inferred that MacLean's sampling was poorly

No.	Location	Character	Width
			Feet
1.	North end of open cut.	Schist.	10
2.	" "	Yellow oxides, quartz and schist.	3½
3.	Wall of open-cut at top of shaft. .	Schist, very little quartz.	9
4.	East wall of open-cut 50 feet from shaft.	Yellow oxide and quartz.	5
5.	Face of drift.	Quartz.	2
6.	35 feet from face.	Schist with quartz.	4½
7.	50 feet from face.	Quartz vein.	2
8.	110 feet from face.	Pyritized dyke.	2
9.	Mineral zone west of drift at junction of crosscut.	Schist with quartz stringers.	20
10.	Mineral zone east of drift at junction of crosscut.	Schist with quartz stringers.	25
11.	Hanging-wall (?) of mineral zone	Schist.	10

*Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1929, pt. A, pp. 2-4. MacLean, T. A.: "Lode Mining in Yukon", Mines Branch, Dept. of Mines, Ottawa, 1914, pp. 20-31.

done. Many others, including the writer, have since sampled the property with results closely checking those of MacLean. The writer took eleven samples from different parts of the property and on assaying these all proved blank. The details are in table on the previous page.

Gold specimens may be obtained from the workings from which the last seven samples were obtained. In addition a grab sample was assayed showing some pyrite and galena, but no free gold. This yielded $40 to the ton.

The possibility with regard to the property lies in the fact that if the mill tests are to be accepted there may be a very large tonnage of rock of this grade. There is no apparent reason why mining should be restricted to the widths that it has, as there is no apparent difference between wall-rock and ore. There is thus the possibility of a zone of very considerable width carrying $3 values. Although $3 rock is not attractive in the Klondike if the deposit is limited, it does become attractive if there is exceedingly large tonnage in view. Unfortunately, to ascertain the value of the deposit will mean the expenditure of a considerable amount of money. Ordinary sampling does not give results at all comparable with the mill tests and it would consequently appear likely that the only way to adequately test the property would be to remodel the existing mill and put through it sufficient tonnage from different parts of the hill to test the content. If one of these zones in the Klondike becomes proved there are similar zones in other parts that might prove equally attractive.

Wheaton District

Only two properties were visited in Wheaton district; these were the Export group (formerly the Union and Nevada mines) and the Cariboo group. Both properties are situated on Idaho hill near Annie lake.

The Export group of eight claims is situated on the southern, eastern, and northern slopes of Idaho hill and is owned by C. McConnell. In addition there are two claims owned by Mrs. C. McConnell. The country rock consists of greywackes and argillites of the Laberge series. The ore-bodies are veins and replacements in those rocks. The property is in part a re-staking of the Union and Nevada mines* and there are a number of mineral showings of which the two upper are the most important. These are situated at elevations of 3,625 and 3,500 feet, respectively, and appear to represent two zones with somewhat similar dips and strikes cutting diagonally across the face of the hill. The upper showing is 27 feet wide and consists of a quartz and calcite gangue with pyrite, arsenopyrite, galena, and zinc blende. The better mineralized part consists of a streak 2 feet wide about 7 feet above the foot-wall, but there is some mineral throughout. The lower of these two showings is 22 feet wide and has an approximate strike of 80 degrees with a dip of 50 degrees to the south. There are three streaks from $1\frac{1}{2}$ to 2 feet wide with heavier sulphide mineralization; the balance of the showing is somewhat sparsely mineralized.

Coming down the hill towards Schnabel creek from these showings there are a number of cuts all of which show mineralization and which are supposed to represent the traces of these veins descending the hill. This is, however, uncertain. Several of the cuts show narrow bodies of galena carrying high values in silver. On Schnabel creek are some of the older

*Cairnes, D. D.: Geol. Surv., Canada, Mem. 31, pp. 129-139 (1912).

workings of Union mines, which include two tunnels, one driven 25 feet on a flat-lying quartz vein about 5 feet wide and carrying heavy pyrite mineralization, and the other being caved and inaccessible. There are also a number of narrow veins visible in the canyon of Schnabel creek. The majority of the galena veins are narrow, ranging from 4 to 12 inches. Assays of material picked from these show values ranging as high as 127 ounces of silver, 49 per cent lead, and 6 per cent zinc. A considerable amount of work is necessary in order to prove the relationships of the various showings.

The Cariboo group of three claims, owned by T. Brooks, is about 1½ miles up Schnabel creek from the Export group. There are four open-cuts, the lower two of which indicate a vein striking 35 degrees and dipping 60 degrees to the northwest. In the lower cut this shows a width of 7 feet and in the upper cut of 3 feet with a 2-foot streak of copper-stained rock on the hanging-wall. In the third cut there is a vein approximately parallel to the first and about 10 feet higher up the hill. This appears to be about 8 feet wide, but is not well exposed. The fourth cut was not into solid rock at the time of the writer's visit. The values reported are quite low.

1931

Introductory Note

The following note, by G. A. Young, Chief Geologist, relative to field work in 1931 in Yukon Territory, appears in the Annual Report for the Department of Mines for the fiscal year ending March 31, 1932, page 10:

"H. S. Bostock and E. J. Lees completed the geological and topographical mapping of Laberge 4-mile quadrangle (latitude 61° to 62°, longitudes 134° to 136°). A report by Bostock on the Livingstone Creek placers appears in the Summary Report 1931, Part A; preparation for publication of the geological and topographical map of the Laberge quadrangle is now under way. Bostock also investigated a discovery of lode gold about 50 miles northwest of Carmacks and has given an account of the discovery in Summary Report 1931, Part A."

In the Summary Report for 1931, part A, page 111, the following paragraph is included under "Other Field Work":

"*E. J. Lees*. Lees, under the supervision of H. S. Bostock, completed the topographical and geological mapping of the Laberge 4-mile quadrangle (latitudes 61° to 62°, longitudes 134° to 136°), Yukon. A report and map are being prepared*."

THE MINING INDUSTRY OF YUKON, 1931

by H. S. Bostock

During the 1931 field season the writer was mainly engaged on work connected with the geological and topographical mapping of the Laberge map-area and, therefore, could devote little time to the collecting of information regarding the progress of the mineral industry in Yukon. It was possible, however, to make a brief examination of Livingstone placer camp and of the lode gold strike made in 1930 northwest of Carmacks.

Livingstone Placer Camp

Livingstone is the site of a placer camp that has been of some importance in the past. Gold was first discovered in the vicinity in 1898 and since then a very considerable amount is said to have been taken from the creeks in the neighbourhood. At the present time Livingstone, once a booming placer camp, consists of a dozen or more cabins in various stages of dilapidation and is inhabited by a half dozen prospectors and trappers. During 1931 a little hydraulicking was done on Lake creek and the results are reported to be encouraging. Some development of a similar nature was also begun on Little Violet and Summit creeks. During the last two summers several families of Indians were occupied intermittently in "sniping" among the old diggings of the creeks. The camp is on the east side of the valley of the South Fork, Big Salmon river, and is about 52 miles directly northeast of Whitehorse. It was examined in 1901 by R. G. McConnell and his report was published in part A, Annual Report, volume XIV, of the Geological Survey. The present writer paid a brief visit to the camp in 1931. The information gathered by the writer is supplemented in this

*Bostock, H. S., and Lees, E. J.: Laberge Map-area, Yukon; Geol. Surv., Canada, Mem. 217, 1938.

report by that contained in the report of R. G. McConnell and by a few details from unpublished notes made by D. D. Cairnes in 1907.

Five routes have been used to reach Livingstone. The most important route follows Teslin river from Hootalinqua at the confluence of Teslin and Lewes rivers, for 19 miles upstream to Mason landing, and from there crosses by a rough wagon road the ridge that separates the valleys of South Fork and Teslin rivers. This road is 14 miles long and the summit of it is at about 3,900 feet elevation, or nearly 2,000 feet above Teslin river and 1,300 feet above South Fork river. Another route frequently used at the present time is that of the winter road from Whitehorse which strikes Teslin river at Winter crossing, 16 miles above Mason landing, and reaches Livingstone 11 miles farther along, by a pass 2,800 feet in elevation. A third route is an old trail from the south, which connects with Teslin river near Boswell. The other two routes have now fallen into disuse. One ascended Teslin river to Seventeenmile cabin and crossed the ridge by a pass some miles north of the road from Mason landing. The other followed Big Salmon and South Fork rivers, but these two streams are difficult to ascend and now only the section of the route on the Big Salmon is sometimes used going downstream. A trail leads easterly up Livingstone creek to Quiet lake and other trails connect with the workings on various creeks.

The head of the South Fork is in the mountains southeast of Livingstone. In the upper part of its course it runs westward to join Fish creek. At the junction it turns northward and follows a wide main valley to Big Salmon river. At Livingstone the valley of the South Fork marks the border between the mountains to the east and the Yukon Plateau region to the west, though the plateau surface is represented along the eastern side of the valley by rounded ridges extending westward from the mountains. Where the wagon road crosses it the valley extends approximately north and south and has a comparatively flat floor about 2 miles wide. West of the valley flat, the land rises moderately steeply to form the ridge between it and Teslin river.

Along the east side of the flat valley floor a ridge rises 200 to 300 feet high and extends from Martin creek to Cottoneva creek, though broken by several gaps. East of this ridge, between it and the foot of the mountain slopes to the east, runs a narrow valley. From the east side of this narrow valley the main valley wall rises abruptly for 1,500 feet, above which it rises more gently in ridges that slope upwards to elevations of between 5,000 and 5,500 feet. The summits of these ridges are remnants of the Yukon plateau. Farther to the east the mountains rise an additional 1,000 feet in the form of a range of originally more rounded eminences whose northerly slopes, once occupied by alpine glaciers, are cut into by cirques divided by sharp ridges and surmounted in places by rugged peaks.

The creeks entering the main valley from the east occupy hanging valleys and this is also true of the head of the South Fork itself to the south above the junction of Fish creek. These valleys have gentler gradients, are broader, and their bounding slopes are less steep in their upper parts than in their lower western sections where they drop abruptly into the main valley of the South Fork.

Evidence of continental glaciation is present throughout the district in the form of a mantle of till on the gentler slopes and the tops of the ridges, and the presence of erratics which occur at all elevations. An erratic found on the highest point reached in the neighbourhood, over 7,000 feet, shows that the ice at its maximum reached above this elevation. A few striæ observed in the surrounding country indicate the direction of movement of the ice to have been towards the north and northwest and down the valley of South Fork river. The valleys in the mountains are typically U-shaped in cross-section. Their floors are covered by moraines and fluvial deposits. The cirques at their heads are evidence of alpine glaciers subsequent to the continental glaciation. The valley of the South Fork is filled with stream gravels which are pitted here and there by kettle-holes.

General Geology

The valley of the South Fork at Livingstone also marks the geological boundary between the rocks that form the plateau region on the west and those that compose the mountains on the east. On the west side of the valley the rocks are of the relatively unmetamorphosed volcanic and sedimentary formations that form most of the plateau region between lake Laberge and Teslin river. On the east side of the valley, a series of intensely metamorphosed sedimentary and igneous rocks occur, which dip towards the valley and, apparently, pass beneath the strata that outcrop on the other side of the valley 2 miles to the west.

The general features of these rocks as given here are based on rather limited field observation. The lowest members of the section dealt with occur at the head of Livingstone creek and northward along the ridge that separates it and the heads of the other tributaries of the South Fork between it and Mendocina creek from the upper part of Mendocina creek. These rocks are a group of basic and ultra-basic igneous rocks and schists, diorite, pyroxenite, and peridotite being among the varieties noted. They are all intensely fractured and sheared, and chloritic schists occur among them. Numerous segregations of magnetite were noted in the ultra-basic types. To the west of these rocks, the hills are formed of grey, quartz-mica schists, white and grey schists, and sheared quartzites. A number of lenses of limestone are interspersed through their eastern members. To the west is a belt of green, sheared rocks chiefly of igneous origin, foliated diorite and diabase types with green, chloritic schists occurring among them. Farther west these rocks are followed by grey, quartz-biotite schists, white and light grey sericite schists, and lead-coloured argillites, succeeded by a second series of green rocks, mostly tuffs, and these by a band of interbedded cherty quartzites and limestones with some cericitic, chloritic, talc and graphitic schists among them. The schists and associated quartzites and limestones strike approximately north 30 degrees west and dip from 20 to 60 degrees to the west. R. G. McConnell remarks that the schists are partly of igneous and partly of clastic origin and resemble in a general way the gold-bearing schists of Klondike district. Many lenses of vein quartz carrying small quantities of sulphides and in some cases visible free gold, occur in the schists and seem to be more abundant in the western members.

The schists of the north part of the ridge referred to above are cut by some small bodies of granitic rocks and in the mountains to the southeast of Livingstone at the head of the South Fork these rocks occur in bodies of batholithic dimensions.

The original source of the placer gold, found in the creeks flowing from the east, is most probably the quartz veins in the schists. The majority of these are small lenses a few inches wide and only a few feet long. In places, however, they were noted to be over 2 feet wide and more than 100 feet long. It is said that some of these small veins were discovered to be very rich in free gold, but that when such small lenses with high values were taken out no visible continuations remained.

Placer Deposits

The creeks that are reported to carry gold are St. Germain creek on the left bank of the South Fork and all those from Mendocina to May creek, a distance of 12 miles, on the right bank. The creeks from Little Violet to Livingstone appear to have been the most productive.

Livingstone Creek

Livingstone has been by far the most productive of the creeks. No records of production are available, but 'old timers' say that this creek produced over $1,000,000 in gold. The creek flows westerly to where at the edge of the main valley it enters the narrow valley at the foot of the main slope, which it follows north for 2 miles before again turning west and breaking through the flanking ridge on the west. The stream where it turns north after leaving the hills is about 15 feet wide and above this point is 6 miles long. It heads in a cirque and from there for about 3 miles it follows a shallow, U-shaped valley with a gradient of about 100 feet a mile. Lower down, the valley takes on a V-shaped section and narrows to a canyon for the last three-quarters of a mile before it turns north. In the narrower part of the valley and in the canyon the floor is 50 to 100 feet wide and in the canyon the gradient increases to a maximum of about 500 feet a mile. In the lower part of the canyon, rock outcrops on both sides, but towards the head the south wall is composed of a great thickness of sand, clay, gravel, and till with large boulders.

The old workings are in the lower mile or so of the canyon. Their history is said to have been one of alternate periods of rise and decline in production from 1898 to 1920 when production virtually ceased. The better ground was in the lower part of the canyon where the creek flows between the rock walls. As this became worked out production began to decline and higher up the channel of the creek was yielding even poorer results. Shortly afterwards, however, an old channel with good pay was discovered under the overburden on the south side a little below the head of the canyon. This channel was on bedrock a few feet higher than the present creek channel where they joined. It was found to extend upstream, but its gradient was more gentle than that of the present creek channel and half a mile or so above its lower end the old channel was 40 feet below and over 1,000 feet to the south of the present channel with a rim of bedrock rising between them. The old channel lay under a great depth of frozen ground, though the pay gravels at the bottom were unfrozen. The pay-streak in the old channel is said to have been on the average about 30 feet wide and 2 feet deep. Since the pay gravels lay in a stream channel cut in rock it is probable they were of pre-Glacial age like those found on Lake creek, which are described later. The old channel of Livingstone creek was at first worked in separate claims, some of which had long adits and inclines extending southerly from the present channel. The upper claims were difficult to work on account of water, the pay gravels being unfrozen and below the level of the entries on the creek. These circumstances finally led to amalgamation of these claims and the connecting of the workings for drainage and operating purposes, and once more operations revived. As the old channel was followed up the gold was found to become finer and scarcer, rich patches such as were present in the lower part did not occur, and the channel no longer paid to work. Finally an attempt was made to work these claims on the old channel by hydraulicking the whole channel, but the great depth of frozen overburden and the doubtfulness of the returns led to the abandoning of the project soon after it was begun.

Some distance up the creek, abreast of the workings on the old channel of the south side, another buried channel is reported to have been discovered. An adit was run into it, but the results are not known and in spite of the ground being reported to be unfrozen it appears to have been abandoned without much work being done.

At the mouth of the canyon where the creek turns abruptly north rich ground is supposed to exist and in the past an attempt was made to test it. A steam plant and pumps were installed and a shaft was put down with great difficulty—owing to water and great boulders—to a depth of 70 feet and abandoned before reaching bedrock.

The gold from the creek was very coarse as a whole and a number of nuggets were found worth over $200 each and some over $400. The gold had a dull, copperish tinge and the average assay value is stated to have been $18.20 to the ounce*. A few nuggets showed a rough surface and included fragments of quartz, but as a rule they were worn quite smooth. A great deal of magnetite in coarse lumps and as sand was present with the gold. This magnetite came from the ultra-basic rocks at the head of the creek. Small quantities of galena, native copper, garnets, and cinnabar are also said to have occurred with the gold.

Lake Creek

During the season of 1930 Mr. T. Kerruish took up a placer lease on Lake creek and the work on this lease has been the chief development in the camp during the last two seasons**. The valley of Lake creek has a relatively gentle gradient in its upper part, but as it approaches the main valley of the South Fork it enters a narrow canyon and drops steeply to the level of the side valley already referred to. The present development, as well as the old workings, is all above the canyon. In the past this creek is reported to have produced many thousands of dollars in gold taken from an old channel in which the paystreak was said to be about 15 feet wide and to lie close to the present course of the creek on its north side. The old workings, the results of several successive independent owners, burrowed irregularly through the old channel and a number of very rich pockets were removed, leaving intervening patches of ground untouched. Though the total depth of gravels was only 15 to 30 feet and though they were unfrozen and contained only a few large boulders, hydraulicking was not used as the creek is small. Mr. Kerruish, however, has made a reservoir on it and has put in a small hydraulic plant which has proved very successful. The effectiveness of the hydraulic plant was enhanced in 1931 by the wet season which provided an unusually prolonged flow of water in the creek. During the past two seasons a long cut 20 to 30 feet wide was made, extending up the channel followed by the old workings. The returns are reported to be very satisfactory and this work has shown that the old chan-

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*McConnell, R. G.: Geol. Surv., Canada, Ann. Rept., vol. XIV, pt. A, p. 28.
**Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1930, pt. A, p. 2.

nel is wider than formerly supposed, as the north edge has not been reached yet.

At the time of the writer's visit the top 10 feet or more of drift over an area adjacent to the present cut on the north side was being cleared off in preparation for a similar cut next spring, as the limits of the pay channel in that direction appear not to have been reached yet and the ground is virgin. The section on the north side of the cut is about 30 feet thick to bedrock. At the top is 16 feet of glacial till. This overlies 6 feet of poorly sorted gravels containing rounded fragments some of which are of foreign material. This in turn lies on 6 to 8 feet of gravels and sand of a distinctly rusty colour and composed only of local bedrock material, the fragments of which are angular in form and seldom over 12 inches long. Fortunately the whole section contains only a very few large boulders. The rusty gravel lies on bedrock which is decomposed and soft for a depth of a few inches to a foot and can easily be shovelled off the harder rock beneath. The extent of the layer of rusty gravel is uncertain. It is considered to be of pre-Glacial age and to have escaped disturbance by the ice owing to its sheltered position in the bottom of this small valley whose course is transverse to the direction of movement of the ice. As is the case in most of the creeks the schist bedrock strikes across the course of the stream and forms a very favourable surface for the retention of the gold. The rusty gravel is regarded as the paystreak. The gold in it has a copperish tinge and the occasional fragments of quartz enclosed in it are rusty brown. Most of the gold is fairly coarse, and occurs as flat flakes or nuggets with smooth surfaces. The gravels above the paystreak are also said to carry gold, but it is finer, brighter, and yellower, and forms pieces of irregular shape in many cases containing white quartz.

Summit Creek

Summit Creek valley is somewhat similar to Lake Creek valley. The old workings are just at the head of the canyon and do not appear to have been so extensive as on Lake creek. From time to time work has been carried on and during the season some development was in progress.

Little Violet Creek

Little Violet creek, the northernmost of those visited, is small and runs down a narrow valley with a steep gradient which becomes still more steep at its lower end where it drops to the level of the main valley. Some old workings lie above the steeper part of the course and some development work is being started on the creek at the present time. Rusty gravels similar to those on Lake creek outcrop along the creek. The flow of water is small and many boulders make it difficult to work. Because this creek is to the north of the others and the strike of the formations is west of north, the bedrock along it belongs to more easterly horizons than those under the workings of Lake, Summit, and Livingstone creeks. The schists here are less foliated and contain massive members and dykes that form inferior surfaces for the retention of the gold.

Cottoneva Creek

Cottoneva creek is one of the larger creeks of the camp, but its more gentle gradient and the large quantities of coarse gravels have made it difficult to work. However, a considerable amount of work has been done along the creek, for which a relatively large amount of hydraulic and derrick equipment was required. As the result of this the work proved too costly and has been at a standstill for some years. Some exposures of rusty gravels were noted on a soft, decomposed bedrock. The present creek gravels hold a conspicuous quantity of vein quartz and between this creek and Little Violet a number of quartz veins outcrop along the foot of the valley.

Several important factors appear to have contributed to the presence of the placers of the Livingstone camp. The factors that led to the formation of the placers in the first place were: the presence of the quartz veins in the schists, providing a source for the gold; the very long period of erosion prior to the Pleistocene, during which a great thickness of rock was eroded concentrating the gold in the gravels and on the bedrock surface; the cleavage and stratified structure of the schists and their strike across the direction of the courses of the creeks, giving them an unusually favourable bedrock surface for the retention of the gold. The factors that led to the preservation of some of the placers from disturbance by glaciation were: the sheltered positions of the placers in the bottoms of the valleys; the courses of the streams being east and west and transverse to the direction of the movement of the ice; the spurs separating the valleys being high and steep and particularly so on the south side of Livingstone creek, from which direction the ice moved. As a result of these factors the valley bottoms containing the placers were filled with gravel and till and were overridden instead of being scoured by the continental ice-sheet. Another factor contributing to the preservation of the placers was that the mountains at the heads of the streams were not sufficiently high to cause valley glaciers that would have removed the placers after the recession of the continental ice-sheet. An exception to this was Livingstone creek, where fortunately, the valley glacier did not extend far down the creek.

Gold Strike Northwest of Carmacks

In 1930 a lode gold strike was reported near Carmacks and attracted considerable attention. The locality is in the east end of the Dawson range and lies about 38 miles northwest of Carmacks by the trail up Crossing creek. The trail follows the road from Carmacks for 10 or 11 miles towards Yukon Crossing and then turns off to the northwest and cuts over a low ridge into Crossing Creek valley. After fording the creek it turns west along the north side of the valley, follows the creek to its head, crosses over the divide and continues for several miles down the valley of Seymour creek, a tributary of Big creek. The latter half of the trail is wet and very little cutting has been done on it. Another route from Carmacks follows the Nansen Creek trail as far as Rowlinson creek, branches off there, and follows up Rowlinson creek and through a pass to the head of Seymour creek. This route is longer and reported to be no better than the other.

In 1917 a small placer stampede took place into the valley of Seymour creek. Though this produced no directly profitable returns it aroused the interest of some of the prospectors in the locality and since then two or three have returned from time to time to look over the surrounding country. Mr. F. Guder, who was one of these, discovered some magnetite float carrying visible gold on the top of the ridge north of Seymour creek. In June, 1930, after he had discovered it in place, he staked the first claim, the Augusta. After staking of this claim the interest in the locality steadily grew until by the beginning of 1931 well over one hundred claims had been recorded. The locality was visited by the writer in the beginning of September, 1931. During the summer the assessment work had been done on many of the claims and a few mineral showings discovered.

Most of the claims are located along the top of the ridge which forms the north side of Seymour Creek valley and separates it from Stoddard creek, another tributary to Big creek. The slopes of the ridge rise steeply out of the creek valleys, flatten towards the upper part, and steepen again along the backbone of the ridge. The ridge is steepest on the south side. On the north side the slopes are more gentle and conform with the general northward slope of the whole country. Most of the outcrops occur on the steep lower slopes and here and there along the backbone of the ridges and spurs where in many places the outcrops have a castellated appearance from a distance. The gentler slopes are covered by a mantle of soil and disintegrating rock in which trenches have been dug several feet in depth before reaching rock in a solid condition.

General Geology

The ridge on which the claims are staked is composed of a series of metamorphic rocks, and a number of bodies of younger, coarse-grained, intrusive granitic and syenitic rocks. The metamorphic series was observed to extend a few miles north and is reported to cover large areas to the north and west. The younger intrusive rocks occur over a considerable area to the south and east.

The metamorphic series in the area examined consists, in the main, of gneiss and quartzite. The most of the gneiss is composed of light and dark bands which give it a stratified appearance. The dark bands are the thicker and are usually several inches broad, whereas the lighter material forms bands $\frac{1}{4}$ to $\frac{3}{4}$ inch thick. The dark bands are composed of feldspar, some quartz, considerable quantities of hornblende and less of biotite. The light bands are largely of fine-grained, granitic, and aplitic material consisting of feldspar, quartz, and a very little hornblende. The gneiss is foliated parallel to the banding. A considerable amount of unbanded, foliated gneiss of a generally lighter colour and containing more feldspar and quartz is also present. It contains both orthoclase and plagioclase, and equal amounts of biotite and hornblende. The gneiss is cut by unfoliated, scattered aplite and pegmatite dykelets which tend to follow the foliation, usually crossing here and there at a slight angle. In places the rock is traversed by a network of epidote veinlets. The quartzite is thinly bedded in the form of white to light grey layers separated by dark grey to nearly black seams of schist from $\frac{1}{16}$ to 1 inch thick. This schist is composed of quartz and mica with graphite in some seams. Some float of similar schist from thicker beds was also noted. A single boulder of limestone was found on the surface of the area in which the quartzite outcrops and indicates that limestone probably occurs with the quartzites. The gneiss and quartzite are closely folded and vary in dip and strike within almost every outcrop. The quartzite occurs chiefly on the south of the gneiss, but no regular boundary could be traced between them. In all probability they belong to the Yukon group (Precambrian). They are cut by a number of small, diorite dykes. In the immediate vicinity of the magnetite showings on the Augusta claim the surrounding gneiss and quartzite have been much metamorphosed, the metamorphic silicates, garnet, actinolite, and epidote, have been produced and magnetite and specularite have been introduced.

The younger, intrusive series consists of stocks of syenite porphyry, large bodies of granodiorite and granite, and numerous small dykes. Typically the syenite porphyry is very coarse-grained and composed of large, pink, orthoclase phenocrysts in a grey, coarse-grained groundmass of orthoclase, plagioclase, and hornblende. The orthoclase phenocrysts are chunky in form, usually $1\frac{1}{2}$ inches, but in some places $2\frac{1}{2}$ inches, long. They are scattered abundantly through the rock and in some places show the parallel alignment of flow structures. The hornblende is dark green to black. The plagioclase is an oligoclase; it is thickly clouded with alteration products and this is also true of the orthoclase though to a less degree. Orthoclase is more abundant in the groundmass than the plagioclase. A little quartz fills the interstices between the other minerals. Titanite and apatite are present in small quantities. Magnetite occurs as scattered grains of irregular outline, equally abundant in all the essential minerals. Minute fractures traverse the rock and strain shadows occur in the quartz. In several places the rock was noted to be so crushed that its original characters were largely obliterated and the rock consists of large, cracked grains of feldspar, remnants of the phenocrysts, embedded in a meshwork of fine, chloritic material, the whole being traversed by numerous, small veinlets of epidote.

In the case of the syenite porphyry stock outcropping on the summit of the ridge northwest of the Augusta claim, the porphyry slowly changes as the contact with the metamorphic series to the west is approached. The size of grain and the quantity of orthoclase decrease, whereas the amount of hornblende increases, making the rock close to the contact a hornblende syenite of a dark grey colour and uniform grain with a slightly developed ophitic texture. Fragments of gneiss were noted in it close to the contact.

The second body of syenite porphyry lying southeast of the abovementioned stock outcrops in only a few places, but the area is covered with its float except for stretches where a very large proportion of the float is of dyke rocks such as varieties of diorite, rhyolite, quartz porphyry, and granite. The fragments of the diorite may come from inclusions of older rocks in the syenite porphyry, for in the metamorphic series a small dyke of syenite porphyry was found intruding a small dyke of diorite. The other types represented in the float are almost certainly dykes, judging from the distribution of their float and the occurrence of similar rocks as dykes in the other bodies of syenite porphyry and other rocks. In the southwest corner of this body of syenite porphyry the rhyolite and quartz porphyry float is so abundant that these rocks must make up the major portion of the bedrock.

The most easterly of the three bodies of syenite porphyry contains slightly less hornblende and more quartz than the others. It extends a considerable distance eastward. Dykes of granite and granodiorite cut the eastern body. No mineralization was observed in the syenite porphyry bodies.

The granodiorite and granite form the spurs and lower slopes of the ridge on the Seymour Creek side and are part of an extensive area of these rocks that continues in the hills on the north side of the trail as far east as the ford on Crossing creek and probably forms much of the range to the south. The rocks vary from a grey granodiorite of orthoclase, plagioclase, quartz, hornblende, and biotite to a light pink granite of quartz, orthoclase, plagioclase, and a little mica, but for the most part the types are distinct. It was noted that the outcrops on the lower slopes of Seymour Creek valley from about 3,500 feet downward, and the eastern body, are of granodiorite, whereas along the top of the slope adjacent to the contact with the older rocks they are of granite. The granite and granodiorite are younger than the syenite porphyry bodies, for they cut them in the form of dykes. The granodiorite and granite in turn are cut by dykes of rhyolite, quartz porphyry, lamprophyre, and andesite and by small bodies of aplite and pegmatite.

No sign of glaciation was found upon the ridge on which the claims occur, the general limit of glaciation lying a few miles to the south on the other side of the Dawson range. A tongue of the ice-sheet, however, extended through the range by way of the gap at the head of Rowlinson creek, into the heads of the valleys of Crossing and Seymour creeks. It carved the upper part of Seymour Creek valley, truncating the lower ends of the spurs and giving rise to a U-shaped cross-section, and left an area of glacial debris whose uneven surface gave rise to the lakes at the summit between the two creeks. Since the ridge on which the mineralization has been found was not glaciated, the mantle of soil and rock debris has remained undisturbed since pre-Glacial time. For this reason the sources of float where the slopes are gentle lie directly beneath or a short distance up the slope.

Economic Geology

As many of the claims were staked on the snow in the winter and much of the ground is devoid of outcrops, most of the prospecting so far done on the claims has consisted of trenching to find the type of underlying bedrock and the source of mineral float. In this way the magnetite showing on the Augusta, Badger, and Morning claims, a galena vein on the Red Fox claim, and veins on the Rambler and Nabob claims have been found.

Augusta Claim

The best developed mineral deposit is that of the original discovering of the Augusta. The chief showings of this are on the top of the west end of the main ridge between 4,100 and 4,500 feet elevation. The ground slopes steadily downward from the showings to the west and northwest and rises to the east 50 feet or more to a rounded summit. The rocks immediately around the deposit are those of the metamorphic series. The magnetite, which is the chief mineral of the ore, has been exposed in place in six short trenches and a number of shallow pits which are distributed down the slope to the northwest for several hundred feet from where the original find was made near the top of the ridge. Magnetite float has been traced for over 1,000 feet farther to the northwest beyond the excavations along the same line, but it does not continue more than 50 feet to the southeast from the highest trench. The highest trench is the largest working and it is approximately 5 feet wide and 8 feet deep and 30 feet long across the line of the float. The magnetite is exposed throughout its length and breadth, the trench ending as soon as the wall-rock is reached. The next two trenches are about 60 and 125 feet away respectively down the slope. The magnetite shows a width of 12 feet in the upper trench and 6 feet in the lower. In the remaining excavations down the slope the full width of the magnetite is not displayed.

The deposit is of the contact metamorphic type and of the magnetite variety*. The minerals present in the ore are magnetite, quartz, specularite, limonite, free gold, actinolite, garnet, and epidote. The magnetite occurs as perfect crystals embedded in limonite or as solid areas of interlocking crystals traversed by veinlets of limonite. The magnetite crystals frequently show a series of alternating pure and less pure zones of growth about a pure central core. The limonite occurs irregularly distributed among the magnetite. It is in solid patches, vein-like masses, or networks surrounding magnetite or cavities in which it forms a cellular structure in some instances. No sign of pseudomorphs of former minerals could be detected in the limonite. The quartz is glassy and crystalline. It occurs as small veins and patches in the magnetite and limonite, usually showing a comb structure and in many cases surrounding vugs into which its crystals project. A little specularite occurs with the quartz and silicates in the ore, but it is much more abundant in the wall-rock where it is in large flakes forming veins and patches among the silicates. The gold occurs here and there as small patches visible to the unaided eye. These patches are scattered through the limonite and under the microscope numerous minute particles can be seen around larger ones. Gold was noted adjacent to magnetite, but never in it. Tiny wires and films of gold also occur between quartz crystals in the vugs. Small patches of silicates, including yellow brown garnet, occur in the ore, but they form a large proportion of the wall-rock. The wall-rock in which the metamorphic silicates occur consists of altered quartzite and schist of the metamorphic series, but gneiss outcrops approximately 60 yards to the north. One boulder of limestone was found about 30 yards down the slope to the southwest. It consisted of finely crystalline, blue-grey limestone with a portion of an adjacent bed composed of metamorphic silicates and specularite adhering to it. The walls of the deposit appear to be sharp but irregular and the dip is uncertain. The present excavations do not reach below the zone of weathering which is unusually deep for this northern latitude on account of the lack of glaciation. It seems probable that the limonite has formed from the weathering of iron sulphides which carried the gold and that when greater depth is reached, where the alterations due to weathering are less complete, the iron sulphides will be found in place of limonite.

Two other showings of similar magnetite occurrences have been discovered by trenching—one on the Badger and one on the Morning which lie respectively north and northeast of the Augusta. The extent and form of these are unknown.

No evidence as to which of the large intrusive bodies in the immediate neighbourhood contributed to the mineralization was found. The magnetite deposits lie between two bodies of syenite porphyry and magnetite is abundant in the porphyry. Possibly the mineralization owes its origin to the syenite porphyry.

Red Fox Claim

A small vein containing galena has been found on the Red Fox claim on the south side of the head of Guder creek. The vein is exposed in two cuts approximately 30 feet apart on the steep side of the draw. It strikes approximately east and dips nearly vertically. It is 6 to 8 inches wide and composed of lumps of sheared galena between which limonite and gouge occur, the

*Lindgren, W.: "Mineral Deposits", 3rd Edition, p. 801.

exposures being well up in the zone of weathering. The wall-rock is quartzite. Small amounts of chalcopyrite and sphalerite occur in the galena.

Rambler and Nabob Claims

On the Rambler and Nabob claims quartz veins a few inches to a foot wide containing fine crystals of pyrite have been exposed in place in pits 6 to 9 feet deep. The float of vein quartz and limonite which was first discovered on the surface on the Rambler is reported to have contained free gold.

1932

Introductory Note

The following brief reference to field work in 1932 in Yukon Territory is given by G. A. Young, Chief Geologist, in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1933, pages 9 and 10:

"H. S. Bostock commenced geological mapping and investigation of Carmacks 4-mile map-area (latitudes 62° to 63°, longitudes 136° to 138°). This quadrangle is one of the as yet unmapped areas most easily accessible to prospectors and in it a gold strike has recently been made. As it lies on the border of the unglaciated region, its examination may also yield results of economic value in connection with placer deposits of the Yukon. Bostock visited Dawson to collect information regarding the mineral industry. A review of mining activities during 1932, prepared by him, appears in Summary Report 1932, Part A, II."

THE MINING INDUSTRY OF YUKON, 1932

by H. S. Bostock

During the field season of 1932 three weeks in August were devoted to visiting Klondike and Mayo districts. The remainder of the season was occupied in the geological mapping of the Carmacks sheet to be published on a scale of 4 miles to 1 inch. In the course of this work a visit was paid to the locality of the lode gold strike made on Seymour Creek in 1930, previously visited in 1931*.

During the visit to Klondike and Mayo districts, the work was greatly enhanced by the gracious assistance of all those met among the Government officials, officials of the mining companies, and prospectors. The writer expresses his appreciation, in particular, to Mr. G. A. Jeckell, Comptroller of Yukon Territory, and also to the officials of the Yukon Consolidated Gold Corporation. Particular recognition is due to this corporation for the privilege of using in this report the information on the gravel reserves and operations in Klondike district. The writer is indebted to Mr. A. K. Schellinger of Keno for his kindness in escorting the writer over the properties on Keno and Galena Hills and for supplying a great part of the information relating to them. Without his assistance it would have been impossible to have collected so complete a record of the activities of this camp in the time available. The writer is also indebted to the officials of the Treadwell Yukon Company, Limited, for their kindness in showing him over the properties of their company.

In Yukon the mineral production of 1932 was slightly below that of 1931, but the activities of the main centres, Klondike and Mayo districts, were maintained. The gold production, which had been rising since 1926 and was $915,969 in 1931, fell to $842,925 in 1932. This drop is said to be due to two of the large dredges in Klondike district being closed down earlier than usual for reconditioning. Over three-fourths of the placer gold production came from Klondike district, the remainder from Sixtymile area, Mayo, Livingstone, and Kluane districts. The only lode pro-

*Bostock, H. S.: "Mining Industry of Yukon", 1931; Geol. Surv., Canada, Sum. Rept. 1931, pt. A, p. 7.

duction is that from the mines in Mayo district. In 1931 this was $1,223,162 or 4,444,774 pounds of lead, 3,674,730 ounces of silver, and 245 ounces of gold. The tonnage shipped in 1932 is reported to be approximately the same as that of 1931.

Placer Mining

Klondike District

During 1931 and 1932 the Yukon Consolidated Gold Corporation has had five dredges in operation. Three of these dredges, all large boats with 17 cubic foot buckets, are on the Boyle Concession in Klondike Valley; Canadian No. 2, approximately a mile below Bear Creek, Canadian No. 3 approximately a mile above the mouth of Bonanza Creek, and Canadian No. 4 on the upper side of Bear Creek. The other two dredges are small boats with 7 cubic foot buckets and are on the Indian River tributaries. One of these, Northwest No. 1, is nearly a mile above the mouth of Caribou Creek on Upper Dominion Creek, and the other, Northwest No. 2, 2 miles below Granville on Granville Flat. In addition the corporation has been operating its hydraulic plants at Jackson Gulch in Klondike Valley and at Lovett Gulch in Bonanza Creek Valley. A number of individual miners were also working on Bonanza, Eldorado, and Hunker Creeks.

During the season of 1932 the Yukon Consolidated Gold Corporation, which with its subsidiary companies now holds almost the entire gravel reserves of Klondike district, employed Mr. E. H. Dawson, consulting engineer and placer expert, to examine their reserves and operations. Mr. Dawson's report was completed in December and it is probably the most comprehensive report ever compiled on the gravel reserves of Klondike district. The corporation has graciously permitted the publishing of the following information derived from this report.

In 1932 the operations of the corporation handled a total yardage of approximately 5,699,800 cubic yards of gravel yielding $685,000. This production was divided approximately as follows: Canadian No. 2, 1,720,488 cubic yards; Canadian No. 3, 842,358 cubic yards; Canadian No. 4, 1,450,665 cubic yards; Northwest No. 1, 562,979 cubic yards; Northwest No. 2, 534,810 cubic yards; and the hydraulic operations, 588,500 cubic yards. As already mentioned, two of the large dredges stopped work unusually early and the following figures are estimated to be the normal full capacity of the present plant: for the three large dredges in Klondike Valley, 1,800,000 cubic yards a year of 180 days each, or a total for the three of 5,400,000 cubic yards; for the Northwest No. 1, 600,000 cubic yards a year of 170 days; and for Northwest No. 2, 700,000 cubic yards a year for 180 days. It is also pointed out that the ditch supplying the hydraulic work is reported to be in a state of poor repair and has a capacity of only 1,000 miner's inches instead of 5,000 for which it was designed, and that this is limiting the hydraulic operations at the present time.

It is interesting to note the following estimated costs as given in the report for 1932: for Canadian No. 2 and No. 3, with thawing, 8.2 cents a cubic yard; and for Canadian No. 4, 6.7 cents a cubic yard without thawing (this dredge was digging naturally thawed ground); for Northwest No. 1, 16.2 cents a cubic yard with thawing; and for Northwest No. 2, 12.4 cents a cubic yard with thawing. Mr. Dawson points out that if the dredges can be kept running steadily for the full season these figures will be cut even lower.

Mr. Dawson points out that for the calculation of the gravel reserves the amount of data on the values of the ground over large areas is very scanty, and for this reason only a small percentage of the ground considered to contain gravel reserves can be classed as proved. A great deal of testing must be done before an exact working estimate can be made. The values that are available, however, are so distributed as to indicate very large reserves of partly tested ground.

A total of 9,740,000 cubic yards of proved and partly proved dredging reserves is given for the Klondike River side of the district on the Boyle Concession and Hunker Creek, and a total probable and possible dredging reserve of 117,296,000 cubic yards, making a total of approximately 127,000,000 cubic yards of dredging ground for the three big dredges on the Klondike side, or enough ground to keep them in operation for over twenty-three years at full capacity. In these figures, however, the large area of untouched ground on the right limit of Klondike River below the mouth of Foster Creek is not included and only a strip 1,500 feet in width along the southern edge of the valley flat between the Anderson Concession at the mouth of Hunker Creek Valley and that of Bonanza Creek is considered as dredgeable. Thus, very large areas of ground in Klondike Valley, which later may be proved to be of some value, have been left out. Another area that it would seem has some value but is omitted from the estimate is the upper part of Eldorado Creek above 27 Gulch, which has not been dredged or worked by modern methods.

Mr. Dawson points out in his report that Mr. McConnell's* estimate of the high-level gravels has proved dependable where it has been tested and that on a number of the high-level benches only a part of the gravel reserves estimated by Mr. McConnell have been exhausted by the hydraulic operations. From the available figures for those hills where sufficient volume is warranted for reopening operations, Mr. Dawson estimates that on Bonanza and Hunker Creeks there still remains a total of 60,247,000 cubic yards of these gravels which should contain a total value of $8,800,000. At 3,500,000 cubic yards a year, which he thinks could be managed with the restoration of the working equipment, this would mean a further life of approximately seventeen years.

The most promising areas of valued dredging reserves occur on the Indian River tributaries where Mr. Dawson reports over 15,811,000 cubic yards of proved and partly proved dredging ground. Most of this lies in Granville Flat and Cruger Concession. The probable yardage of dredging reserves on Granville Flat, Cruger Concession, Upper Dominion Creek, and lower Sulphur Creek is 34,500,000 cubic yards. Besides these areas, the report points out the enormous area of rather unknown territory in Indian River Valley from the Cruger Concession down stream to Ophir Creek, a portion of which is included in the estimates of possible dredging reserves and calculated to be nearly 24,000,000 cubic yards.

Large reserves of gravels are given for Quartz and Upper Sulphur Creeks which cannot be worked by dredging or the usual hydraulic methods and for which other methods are suggested. These reserves total over 4,500,000 cubic yards of proved, probable, and possible classes of reserves and have a total estimated value of $4,500,000.

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*McConnell, R. G.: "Report on Gold Values in the Klondike High Level Gravels"; Geol. Surv., Canada, No. 979, 1907.

Summarizing the reserves, the report shows a total of all classes of reserves of 268,000,000 cubic yards of gravel containing a total value of $54,500,000 in gold.

The total of all the dredging reserves on the Indian River side amounts to 74,311,000 cubic yards. Over fifty years would be required to dig these reserves with the present two dredges with their combined capacity of 1,300,000 cubic yards a year. The question of fuller development of this large and promising area is now receiving attention. If, after thorough testing, these reserves approach the figures of the estimates it is not improbable that eventually the bulk of the dredging operations will become centred on the Indian River side.

It is apparent from Mr. Dawson's estimates that a very considerable increase in annual output of placer gold may be looked for from Klondike district after the next two or three years and that the production can be expected to be maintained for at least two decades.

Sixtymile District

Sixtymile district was not visited, but the following notes have been collected from those in touch with that locality. It is reported that in this district there is an increase in the activities of the placer prospectors and that creeks are again being prospected that have been practically deserted since the discovery of Klondike district.

The dredge installed on Miller Creek in the winter of 1912 by the Northern American Transportation and Trading Company*, and which had been closed down for over ten years, was put into operation by Messrs. Holbrook and Edmundson in 1929** and has been operating since that year. This is a steam-operated dredge of the Risden type with an open bucket line and bucket capacity of 5⅓ cubic feet. Twenty-four men are said to be employed in the operation. The dredge is digging naturally thawed ground on the N.A.T. concession between the mouths of Miller and Glacier Creeks. The returns are said to be very satisfactory.

Placer work is being carried on by individual miners on a few claims above the N.A.T. Concession on Miller Creek. Two and a half to 3 miles of claims are being worked by individual miners on Glacier Creek. Individual miners are at work on Big Gold Creek from the bridge to the mouth and some of these are working deep ground. On Little Gold Creek a 5-mile prospect lease has been granted. Opposite the dredging concession on the left limit is a row of bench claims being held by individual miners, but only one or two were actually being worked during 1932. On Matson Creek one miner has been successfully operating since 1913.

Mayo District

In Mayo district some placer mining was being conducted on Duncan, Haggart, and Highet Creeks. On Duncan Creek Mr. Andrew Johnson has put in a ditch nearly a mile long above the first road house below Keno and a small hydraulic operation was in progress on Upper Duncan on the right limit just at the top of the canyon. Haggart Creek was not visited, but the following notes on the reported activities were collected. Three miles of placer leases are being worked on Haggart Creek and Dublin

*"The Yukon Territory, Its History and Resources"; Department of the Interior, Ottawa, 1916, p. 77.

**Cockfield, W. E.: Geol. Surv., Canada, Sum. Repts. 1929 and 1930, pt. A.

Gulch, the centre of the combined leases being about the junction of the two valleys. These leases were taken up during the autumn of 1931 and spring of 1932. All are being worked by hydraulicking. It is supposed that the values are coming from a pay-streak on the left limit, opposite the old workings. One or two miners are working on the lower parts of Highet Creek, but the chief operations are those of Mr. Elmer Middlecoff on a stretch of ground between Rudolph Gulch and McCreary Pup. The discovery of gold was made in this immediate locality in the autumn of 1903* and some mining has been in progress along this creek almost ever since. Mr. Middlecoff has operated in this vicinity over a period of more than twenty years**. The operation at the time of the writer's visit consisted in extending a cut down the left limit against the steep slope of the valley side. The face of the cut was approximately 30 feet high from the bedrock surface. Bedrock slopes diagonally from the right to the left limit and the rim on the left limit is not yet exposed, though it is evidently only a short distance away. The ground is being worked by an ingenious method developed by Mr. Middlecoff. Previously, various methods had been tried but with varied success. The water condition and the depth of gravel, together with a relatively slight gradient on the creek, made the more usual methods of operating difficult. Two of the chief problems were to dispose of the coarse gravel tailings and to so dispose of them as not to prevent future operations. One of the chief merits of Mr. Middlecoff's method is the solution of these problems. The face of the gravels is attacked with a monitor and the gravels are then blown by the jet of water into and up an inclined box having a suitable size and slope. The bottom of the box is a grating made of large, flat, iron bars set across the box and an inch or more apart. Under the box is a sheet iron tray several inches deep, the lower end of which empties into the sluice boxes. As the gravel is blown up along the length of the box, the finer material and gold fall through the grating into the inclined tray and are washed back along it into the sluice boxes, while the coarser material is blown out at the upper far end onto the tailings pile which is on the ground already worked. Fortunately a head of over 200 feet is available for the monitor and this gives sufficient force to blow everything up to 100 pounds weight up through the box. Heavier boulders are rolled to one side. The monitor is of $3\frac{1}{2}$-inch diameter and 10-inch pipe is used for it. The method disposes of the coarse tailings immediately and cuts down the gravel which goes through the sluice boxes to a minimum. It may result in a relatively low percentage of the total gold values being recovered as some are probably blown over onto the tailings pile, but as it enables this ground to be worked at a profit these losses are justified.

Other Districts

In Carmacks District three partnership groups of placer prospectors have been at work during the last two years on Stoddard and Seymour Creeks, tributaries of Big Creek. The two creeks drain the northeast and southwest sides, respectively, of Mount Freegold, upon which the recent lode discoveries have been made. As yet the placer workings in this vicinity have not proved profitable, though enough gold has been recovered to keep the stakers interested. As far as can be told at present the geology of the

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*Keele, J.: Geol. Surv., Canada, Sum. Rept. 1905, p. 34.

**Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1916, pp. 24, 25.

neighbourhood appears favourable for placer mining possibilities. The area lies just within the limits of the unglaciated region and consequently any placers formed in the long period of erosion extending to the present, have not been disturbed. The rocks consist of a series of gneisses, schists, and quartzites similar to those of the Yukon group to which the rocks of the placer fields of the Klondike and the other important placer districts of the territory belong. These rocks have been intruded in this neighbourhood by a variety of granitic rocks and a large number of mineral showings have been discovered.

In Livingstone district no new developments have been reported. There are, however, a few placer miners working on Lake and Summit Creeks and it is reported that plans are being made to re-open operations on Cottoneva Creek next summer.

Four men are reported to have been working on Iron Creek, a tributary of Sydney Creek which enters Nisutlin River on the west or right limit. They are reported to have been examining some old placer hydraulic ground near the mouth of Iron Creek, about 12 miles southwest of the south end of Quiet Lake. In the past a quantity of equipment was installed there, but no work has been done during the last ten years.

A single miner is reported to have been working for several years on Geary Creek, a tributary of Teslin River which it enters from the west or left limit a little above the mouth of Boswell River.

A revival of activity is reported to have occurred on the placer claims on Squaw Creek, a tributary of Tatshenshini River*. Most of the mining is said to be taking place on the upper part of the creek on the south side of the provincial boundary.

Lode Mining

Mayo District

In 1930, W. E. Cockfield visited and reported on the activities of this district**. The following notes record activities of the camp from that time to the present.

In 1931 and 1932 the bulk of the ore production was from the Lucky Queen and Sadie mines on Keno Hill and the remainder consisted of a small tonnage from the No Cash group on Galena Hill. Prospecting and development have been continued on one or other of the many properties and claims on the hills in the neighbourhood of Keno. This activity is supported by the feeling that if the price of silver were to rise to approximately 50 cents an ounce, it would be possible for these small, rich properties to be worked at a profit.

Keno Hill

The Treadwell Yukon Company, Limited, in 1931 is reported to have treated 47,793 tons of ore in the mill at Wernecke, with a yield of 4,109 tons of concentrates. In addition to the concentrates some 154 tons of crude, high-grade ore was also shipped. All this ore came from the Lucky Queen. In 1932, 1,000 tons of ore were taken from the Sadie mine, the track was then taken out, and this mine abandoned. The rest of the production has come from the Lucky Queen. For the first few months this was

*Cockfield, W. E.: Geol. Surv., Canada, Sum. Repts. 1927 and 1929, pt. A.
**Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1930, pt. A.

from the 200 and 300-foot levels and for the later months of the year from the 100-foot level and above it where a body of ore was recently discovered. This ore contains argentiferous galena as the chief mineral of value; the gangue is quartzite. It was reported that over 4,000 tons of concentrates were to be shipped in 1932. It was expected that the ore in sight in the Lucky Queen would be exhausted in a few months, and as the margin of profit was not considered great enough to warrant any extensive exploration for more ore, the company planned to close the mine, transfer the necessary equipment, and start production from the Brefalt property on Galena Hill. It is reported that the Lucky Queen was closed down about the end of the year (1932).

On the Shamrock group no mining has been done since 1930, but the mine equipment and workings have been kept in good repair.

In the autumn of 1930 and in 1931 Keno Hill, Limited, carried out some development work on the Porcupine discovery made in 1929 and a body of mill ore was developed near the surface. A number of good surface showings have been discovered during the last year or so by tracing the veins across the property of the company.

On the Nabob claim a small amount of surface prospecting has been done each year and has resulted in exposing the continuation of the vein.

On the Stone claim, the long tunnel has been driven through the overburden into bedrock and is now over 400 feet long. It has intersected a vein that contains arsenopyrite, pyrite, and zinc blende, and some fair gold as well as silver assays have been obtained. It is intended to explore this vein further.

On the Peel claim some prospecting has been done resulting in exposing a vein, but the work has been discontinued.

On Mr. Andrew Johnson's Hope Gulch property a tunnel was driven a short distance in 1931 and showed up some galena ore.

Galena Hill

Mining operations on the Silver King and Webfoot claims were continued by the Treadwell Yukon Company, Limited, until about January, 1931, when the option on these two properties was dropped. The bulk of the milling ore was raised and stacked on the dump on the adjoining fraction belonging to the company. At the time the property was visited in 1932 a warehouse had been erected, as it had been intended to build a mill or transfer that at Wernecke to the Silver King. A tramway grade had also been put in between the Brefalt property and the Silver King to transport the ore from the former to the mill on the latter. On the Silver King, however, the ore carries an unusually high percentage of zinc and a penalty is charged for over 10 per cent; this with the low price of silver has prohibited the continuation of the developments on this property.

On the Brefalt property or Elsa group the underground development has been completed since 1930 by putting up raises between the levels. On the surface some buildings have been built including a small hand-sorting plant. The road to the property has been improved and a winter road has been built on a good grade from the Silver King to the Mayo road, which with the tramway grade between these properties will be used to haul out the production from the Brefalt property.

On the Settlemier property some surface development has been carried on and has resulted in the vein being picked up in two trenches 300 feet apart. By these trenches and float the vein has been traced a total distance of approximately 700 feet to the northeast into new territory. One of the trenches shows the vein to have a width of approximately 20 feet with a seam of 5 feet of solid ore in the middle.

On the Betty group the owner has sunk some prospect shafts and has found a lot of good mineral float on the bedrock below 20 feet of overburden. This is thought to come from a possible extension of the No Cash vein.

On the No Cash group the lessee, Mr. E. Bjonnes, continued operations on a small scale in 1931 and shipped somewhat less than 100 tons of ore running about 450 ounces of silver a ton. About 20 tons of ore were shipped in 1932.

On the Tyee claim a little surface prospecting has been going on since 1930.

On Bunker Hill a little development work was continued in 1930. On Sourdough Hill since 1930 nothing but surface prospecting has been done.

Carmacks District

During the season of 1931 a visit was paid to the gold strike northeast of Carmacks and an account is given in the Summary Report, part A, for that year. The strike was again visited in July, 1932, during the course of the field mapping of the Carmacks sheet, a reconnaissance sheet to be published on a scale of 4 miles to 1 inch and covering an area including the lower Pelly River, Selkirk, Carmacks, and Nansen Creek. The mapping was extended to take in the country in the immediate vicinity of the strike and a small sketch map was made to show the geology in the immediate locality of the discoveries. The following notes are given to supplement those in the report of 1931.

The topographical mapping of the Carmacks sheet, under Mr. W. H. Miller, has accurately fixed the position and elevation of Mount Freegold where the original lode discovery was made. The distance to Mount Freegold from where the trail leaves the road 11 miles from Carmacks is 26 miles. The distance by trail from McDade Hill to the mouth of Williams Creek is 14 miles. Another route to McDade Hill leaves the Crossing Creek trail shortly above the ford across this creek and heads northwesterly, passing on the north side two lakes, crosses Merritt Creek, and follows the north side of this stream to its head. By this route it is 20 miles from the road to McDade Hill. There is also a route from Selkirk and Lewes River, by way of Big Creek and its tributary Stoddard Creek. Another route from Carmacks to Mount Freegold is by the Nansen Creek trail 34 miles long. No proper trail has been made along any of these routes. To reach the strike from Selkirk, or if coming up Lewes River, by boat, the best route is probably that by Williams Creek, whereas the best route from Carmacks and for horses is probably the Crossing Creek trail or that past the lakes and up Merritt Creek, depending upon which part of the locality it is intended to reach. The magnetic declination on Mount Freegold was found by Mr. Miller to be between 33 and 34 degrees east of true north and this is close to the average value for the parts of the Carmacks sheet so far covered. He also found that the compass varies widely from this figure locally in some parts of the map-area.

Many of the claims staked in the initial rush in the spring of 1931 have now been allowed to lapse. However, the assessment work has been done on a large number and some active prospecting was in progress in 1932.

A good deal of trenching has been done and a large number of mineral showings have been found, but except those on McDade Hill, they are as yet merely discoveries.

General Geology

The rocks in the area and its immediate vicinity form four divisions, a metamorphic series, a group of older volcanic rocks, granitic intrusives, and a group of younger volcanic rocks. The oldest of these is the metamorphic series referred to in the report of 1931. It consists in the main of gneiss, schist, and quartzite. On either side of Schist Creek these rocks show a persistent strike in a direction between north and northwest and a dip between 45 degrees east and vertical. On the northwest side of Mount Freegold the dips and strikes in those rocks vary very much more and indicate the presence of crumples and small folds. On Schist Creek the series is composed of interbedded gneiss and schist, the quartzites occurring on the west side of Mount Freegold and in the head of Guder Creek. The great part of the gneiss, as well as the schist and quartzite, is thinly bedded. The gneiss is composed of feldspar, quartz, mica, and hornblende. The schist is composed of quartz and mica with subordinate quantities of feldspar. Most of the schist occurs interbedded with the gneiss and smaller amounts with the quartzite. The quartzite is finely crystalline and in some places cherty in appearance. This series is cut off on three sides by bodies of younger granitic intrusives, but extends for an unknown distance to the northwest.

The older volcanics occur in the mountains southwest of Seymour Creek. Their extent here is unknown, but it is probable that they form a large part of the mountains to the south and southwest as similar rocks are recorded as occurring on Nansen Creek, 12 miles south[1].

They are not well exposed here, but elsewhere are known to be composed of andesitic lavas and breccias with some small intrusive bodies of diorite and diabase that are intruded by the granitic bodies. Diorite and diabase dykes grouped with these rocks intrude the metamorphic series on Mount Freegold. The older volcanics are prevailingly green and may usually be distinguished by this colour. They are correlated with those bodies of similar rocks found in other parts of Yukon, that have been grouped under the term Older Volcanics by D. D. Cairnes[2] and W. E. Cockfield[3].

The metamorphic series and the Older Volcanics now form remnants of the roof into which large bodies of granitic rocks have been intruded. These granitic rocks include variations from hornblende syenites, syenite porphyry, granodiorite, granite porphyry, and granite. The syenites are the oldest and form two stocks on Mount Freegold ridge, and a third, larger body extending from the southeast end of the ridge across Seymour Creek and to the mountains directly south. Syenite porphyry is the chief rock of these bodies. It is typically very coarse grained and composed of large, pink orthoclase phenocrysts in a grey, coarse-grained groundmass of orthoclase, plagioclase, and hornblende. The rock varies from this to a hornblende syenite rich in hornblende and plagioclase and, on the other

[1] Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1914.

[2] Cairnes, D. D.: "Lewes and Nordenskiöld Rivers Coal District"; Geol. Surv., Canada, Mem. 5 (1910).

[3] Cockfield, W. E.: "Whitehorse District, Yukon"; Geol. Surv., Canada, Mem. 150 (1926).

hand, to phases holding considerable quartz and very little hornblende. Where the two stocks have intruded quartzites on the west side of Mount Freegold, a considerable amount of contact metamorphism occurs, as evidenced by the presence of garnet, actinolite, and epidote, and with them, magnetite, specularite, pyrite, and chalcopyrite.

The intrusion of the syenite porphyry bodies was followed by the intrusion of a great, composite batholith of granites, granodiorites, and their porphyry phases. These rocks stretch continuously 18 miles to the east, almost to Yukon Crossing. The many varieties of these rocks and the ways in which they are distributed, render it probable that the batholith is composed of a succession of intrusions closely related in composition and in age. Besides varying in composition it was noted that these granitic bodies near their contact with the metamorphic series, include numerous xenoliths of these rocks and in many places possess a foliated structure. Since these granitic rocks are younger than the older volcanics and in general resemble the Coast Range intrusives, it is probable that they and those granites near Selkirk mentioned by D. D. Cairnes[1] are correlatives of the Coast Range intrusives.

The intrusion of the granitic rocks was followed in this region by a great period of erosion which was interrupted by the deposition of conglomerates and sandstones in some of the valleys and by the accumulation of a great thickness of volcanic rocks, chiefly basic lavas and breccias and tuffs. These lavas cover extensive areas between Mount Freegold and Carmacks and have been described by D. D. Cairnes under the name Carmacks volcanics[2]. They have also been grouped by Cairnes and Cockfield under the Newer Volcanics[3]. The areas covered by these rocks have few possibilities and are not recommended for prospecting, since little mineralization of value has ever been found in them in Yukon or in similar rocks in British Columbia, whereas mineralization has frequently been found associated with all the other formations mentioned here.

Mount Freegold and McDade Hill lie in unglaciated territory very close to the western limit of glaciation. If the area has been glaciated it was at a period so much earlier than that of the glaciation recognized that all ordinary traces of it have since been obliterated by normal erosion. The fact that Mount Freegold lies outside the limit of glaciation is an important consideration in prospecting. It means that fresh rock exposures are fewer than in the glaciated areas, but that float is much more easily traced to its origin by following upstream and up slope. It also means that the mineral showings at the immediate surface are likely to be leached of some of their original values in such metals as silver, copper, and zinc, whereas there is a possibility of a residual concentration of gold from the former parts of the mineralization now removed by erosion. This necessitates getting below the surface zone which in some places continues to considerable depths, before truly representative samples holding values likely to continue in depth can be obtained.

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[1] Cairnes, D. D.: Geol. Surv., Canada, Guide Book No. 10, p. 90 (1913).

[2] Cairnes, D. D.: "Lewes and Nordenskiöld Rivers Coal District"; Geol. Surv., Canada, Mem. 5 (1910).

[3] Cockfield, W. E.: "Whitehorse District, Yukon"; Geol. Surv., Canada, Mem. 150, p. 33 (1926).

Mineral Deposits

The mineral showings worked upon during the last year may be divided into three groups: (1) the magnetite deposits of contact metamorphic type in the rocks of the metamorphic series on the northwest side of the summit of Mount Freegold; (2) the pyritiferous vein deposits in the granitic rocks on the south side of the mountain; and (3) the mixed sulphide vein deposit in the granitic rocks on McDade Hill.

Since 1931 a number of trenches have been put in on the claims containing the magnetite deposits. Mr. Guder has traced the line of float from the Augusta where the original showings are, across the Margaret and Gold Star claims, a total distance of over 4,000 feet. On the Augusta the trenches along the line of the float failed to find the magnetite in place beyond a point 200 to 300 feet northwesterly from the main showing at the upper end of the deposit. However, farther down hill, northward along the line of float on the Margaret, in the saddle at the head of King Gulch, a number of trenches and pits have revealed magnetite with hematite, quartz, pyrite, and chalcopyrite in place. Cubical cavities formed from the leaching of pyrite occur in the magnetite on the Augusta. A long trench not yet down to bedrock was being excavated on the Margaret and showed abundant magnetite float. On the adjoining Badger and Morning claims, Mr. W. Langham has started a number of long trenches, but bedrock had not been reached. In these trenches, however, some float carrying magnetite and pyrite in metamorphic silicates was found. No further work was done on the magnetite showings mentioned last year on these claims.

On the Rambler, and the neighbouring claims to the south and southwest being worked by Messrs. W. Langham, G. Fairclough, A. Brown, and others, a considerable amount of surface prospecting has been done. It has consisted of searching for float and trenching. This has disclosed some nine or more vein showings, all of the same general type as that referred to in the report of 1931 on the Rambler and Nabob claims, that is, quartz veins a few inches to a foot wide containing crystals of pyrite. At the time of the writer's visit the best exposed showing was on the Snowflake. Here Mr. Langham has exposed a quartz vein in two cuts on the steep slope of the mountain. In the lower cut, the vein is 5 feet 6 inches wide with stringers in the adjacent granite wall-rock, making a total width carrying vein matter of 10 feet. The vein quartz is very finely crystalline and has a pale bluish grey colour. This colour is due to minute cubes of pyrite and some crystals of arsenopyrite disseminated through the quartz. The vein strikes north 34 degrees east and dips very steeply to the northwest. This was found to be the prevailing strike and dip for the veins of this immediate locality, with one or two exceptions that strike due north. In the upper cut, 30 feet above, the solid vein is 3 feet wide, but stringers occur on either side of it for a few feet. The granite wall-rock here, as well as in the cut below, is much sheared, weathered, and iron stained. Gold colours have frequently been obtained from fragments of the oxidized or partly oxidized vein matter by panning, but though a few spectacularly high assays in gold are reported the majority of the assays reported have been disappointing. Since, however, all these showings are in the most elementary stage of discovery and none of the trenches yet extends below the limit of weathering, considerable work must be done before they can be judged.

On McDade Hill a group of twelve claims have been staked along a single, large, persistent vein. This vein was discovered in 1931 by Mr. G. McDade and since then Messrs. G. McDade, T. Mackay, J. Walsh, and J. Coleman have put down a number of pits and shallow shafts at intervals of 200 to 400 feet along the vein, proving it to continue for at least 4,000 feet. The vein varies between 3 feet and 6 feet in width and has well-defined walls of granite, though in one place bodies of wall-rock are said to divide it into three close, parallel veins. The strike is approximately north 119 degrees east and the dip from vertical to 85 degrees north. One shaft 800 feet east of the creek has been put down 32 feet. This shows the vein to be 4 to 6 feet wide. Here, the vein is composed of quartz with patches of sulphides. The quartz is white, finely crystalline, and contains abundant small cavities which in places are so numerous that the quartz is in a loose, sandy condition. The wall-rock on either side is granite. The vein and wall-rock have everywhere been subjected to intense weathering even to the bottom of the deepest shaft. As a result, much of the original sulphides have probably been leached out and those remaining only occur where the quartz was solid and protected them. The wall-rock has been reduced to a crumbly state, particularly on the south or down hill side of the vein. In some of the pits on the vein the sulphides found are in different proportions. Thus in the shaft mentioned the sulphides seemed to be disseminated, but in the pits on either side they tend to be in large patches. The sulphides occurring in the vein are pyrite, galena, zinc blende, chalcopyrite, and tetrahedrite. Where the galena is found in solid masses it is coarsely crystalline and shows a sheared structure. The chalcopyrite occurs in small amounts associated with the galena. The zinc blende is a resinous variety. The pyrite forms small strings and patches of minute cubes. In places the quartz exhibits a comb structure and contains numerous small vugs amongst which the sulphides are scattered and a vague banding is apparent. Originally particular interest was drawn to the vein by the fact that fine colours of gold could be panned from almost any piece of rusty vein matter on the surface. A number of encouraging assays are reported, but unfortunately the values obtained to date from the majority, though consistently showing small amounts of gold, have not been high enough to class the matter as ore.

1933

Introductory Note

The following note by G. A. Young, Chief Geologist, was incorporated in the Annual Report of the Department of Mines for the fiscal year ending March 31, 1934, page 10, and has reference to field work in Yukon Territory in 1933:

"H. S. Bostock continued geological mapping and investigation of Carmacks 4-mile map-area* (latitudes 62° to 63°, longitudes 136° to 138°). This quadrangle is one of the as yet unmapped areas most easily accessible to prospectors. It is close to the Great Klondike placer mining field and may contain marginal parts of the formation in which the placer gold was found. A lode gold strike of some importance has also been made recently in this quadrangle. The incomplete study of the area has yielded information of value to those searching for placer deposits. This information appears in Summary Report 1933, Part A. Bostock also visited the placer operations in Klondike and Sixtymile districts. A review of mining activities during 1932, prepared by him, appears in Summary Report 1933, Part A."

THE MINING INDUSTRY OF YUKON, 1933, AND NOTES ON THE GEOLOGY OF CARMACKS MAP-AREA

by H. S. Bostock

With the exception of ten days in August the entire field season of 1933 was devoted to the geological mapping of the Carmacks sheet. The ten days were occupied in a visit to the placers of Klondike and Sixtymile districts.

The writer wishes to express his appreciation of the courtesies and assistance extended to him by all those with whom he came in contact, and in particular by Mr. G. A. Jeckell, Comptroller of Yukon Territory, Mr. E. Holbrook, general manager of the Holbrook Dredging Company, Mr. H. A. R. Stewart of Miller Creek, and the officials of the Yukon Consolidated Gold Corporation.

Placer Mining

Klondike District

During 1933 the Yukon Consolidated Gold Corporation continued to operate its five dredges and some of its hydraulic plant. In Klondike Valley the three large dredges operated on the Boyle Concession. Canadian No. 2, starting approximately a mile below Bear Creek, has been working its way upstream into the central part of the valley. In following this course it has been digging small islands of virgin ground left among the tailings by the old small dredges, chiefly Canadian No. 1. In some of this ground these old dredges are thought to have failed to reach bedrock. It is hoped that some ground that will cover running expenses for this dredge for the next year or so will be found among the old tailings and along their north side. In the meantime it is planned to prove and, if possible, thaw ground on the left limit of the valley below Bear Creek for the future operation of the dredge. A large area of low-grade ground is believed to be present

*Bostock, H. S.: Carmacks District, Yukon; Geol. Surv., Canada, Mem. 189, 1936.

in this section but the regular thawing plant method has proved to be too costly for it. To surmount this difficulty a large part of Klondike River is to be diverted and directed over the ground. This is expected to thaw sufficient of the ground for the dredge to operate on it after two or three years. For this purpose a canal has been begun to divert the water from the river below Bear Creek.

Canadian No. 3 has been working on partly thawed ground in the Bonanza Basin above the mouth of Bonanza Creek. It is dredging a narrow strip along the northeast side of the Bonanza tailings. It is intended to try digging the old tailings of the very first dredging done and some islands of virgin ground, in the course of working down to dredge the site of the old camp of the Yukon Gold Company and ground in that neighbourhood. Canadian No. 4 has been working approximately a mile above Bear Creek and is dredging ground between Klondike River and the left limit of the valley. This is expected to occupy it for nearly two seasons. It will then dig its way up to the mouth of Hunker Creek to dredge some ground that has been recently proved by drilling in that vicinity.

The thawing of the ground ahead of the dredges in Klondike Valley has proved a large item of expense and, therefore, advantage is being taken of every possible means of eliminating this cost. The dredges are being directed to dig as far as possible naturally thawed ground. By this method the thawing operations have been reduced to a great extent, and at present Canadian No. 3 is the only dredge in Klondike Valley with a thawing plant working ahead of it. The hydraulic operations were continued this season on Jackson Gulch and on the Lovett Gulch side of Trail Hill. The Twelvemile ditch, however, is to be abandoned as its maintenance has proved too costly and it is planned to discontinue the hydraulic operations until some future date when equipment will have been designed that will provide a better flow of water. In the meantime dredging operations will be carried out on any dredging ground at the foot of Jackson Gulch on which the hydraulic tailings have been spreading out.

On the Indian River side of the district, Northwest No. 1 continued to dig up the valley of Dominion Creek and is now on Fifteen below Upper Discovery. Sufficient reserves still are present up the creek to keep it in operation there for two or three more years. Ground-sluicing and thawing operations continue ahead of this dredge. Northwest No. 2 is working midway between Granville and the mouth of Sulphur Creek on the right limit of Dominion Creek. Here, too, a thawing plant is necessary ahead of the dredge. A change is being made in this plant by installing pumps to supply a greater volume of water with which to ground-sluice the frozen muck before thawing the gravels below with points instead of thawing the whole thickness of overburden with points. It is expected to reduce the cost of thawing very considerably by this change of method. On Quartz Creek a large stretch of ground is being prospected and prepared for dredging. The prospecting is showing good values and the depth of the gravels is generally close to 16 feet and seldom over 20 feet. In the past a considerable area was cleared and the muck sluiced off in the lower part of Quartz Valley. At the present the brush is being cleared off this area and the remainder of the ground is being prepared for sluicing. It is expected that after the removal of the muck the gravels will thaw to bedrock naturally. A dredge using 5-cubic foot buckets is to be installed. To assist these operations water will be pumped from Indian River. Besides these operations the corporation is carrying out prospecting operations with its drills in many parts of its holdings.

During the season of 1933 the corporation has handled a total of 5,341,194 cubic yards of gravel yielding $571,430.23 in gold, at the value of $1=0.048375 ounce. All the dredges began operating on or before May 16 except Canadian No. 3 which did not start until June 29 on account of the frozen ground. Owing to an unusually early freeze-up in October the dredges were all forced to close down by October 19 which made the season an exceptionally short one, but there were no major stoppages. The average percentage of the season spent on digging for the five dredges was practically 90 per cent.

A considerable number of individual miners and small groups encouraged by the higher value of gold were working during 1933 on the creeks in Klondike district. On Bonanza and Eldorado Creeks there were between twenty and thirty-five men employed in this way. The ground worked lies chiefly on Eldorado, Upper Bonanza, and on the rims below Discovery. Gold Run, Dominion, Sulphur, and Quartz Creeks are also providing employment for a number of men.

Sixtymile District

A brief visit was paid to the dredging operation on Sixtymile River and to placers on Miller and Glacier Creeks. This was possible owing to the exceptionally good condition of the road from Dawson to the dredging camp in Sixtymile Valley below Miller Creek. One dredge is operated here by the Holbrook Dredging Company. Directly and indirectly thirty men have been employed by the operation during 1933. The dredge has been greatly improved since it was taken over by the present management and its efficiency much increased. It is run by steam, wood being the fuel. The boiler has a working capacity of 125 horsepower and for the dredge from 6 to 7 cords of wood are burnt per 24 hours. A new bucket line is one of the chief improvements. This consists of a closed line of fifty-two 4-cubic foot buckets instead of the old open line of twenty-eight. The new line weighs approximately the same as the old one but has twice the digging capacity. Another improvement has been the instalment of a modern rubber belt stacker. This dredge will dig to a depth of 20 feet under water. During the writer's visit in August the dredge was being moved up the river to a point just below the mouth of Miller Creek on the left limit of Sixtymile Valley where the ground is more consistently thawed and the areas of pay gravels are better known. The ground in this part of the valley was being stripped of muck to enable it to thaw next spring. Lack of water, however, was a great drawback to the operations during the season. The successful operation of this dredge in a district cut off from hydroelectric power and organized transportation reflects great credit on the management.

A number of individual miners are working along the upper part of Miller Creek and six men, under Mr. H. A. R. Stewart of McCormick, McDonald, and Stewart, on the N.A.T. Concession. On the concession the work is being done on the bench on the left limit of the creek approximately a quarter of a mile up the valley from the Miller Creek roadhouse. This ground proved too deep to hydraulic with the limited amount of water and a tunnel was being driven on bedrock to intersect an area of pay ground known from the findings in some older workings. At the same time some of the shallower ground adjacent to the tunnel was being stripped preparatory for hydraulicking next season. In addition to the operations on Miller Creek six or seven individual miners were working along Glacier Creek and one on Big Gold Creek.

Mayo District

This district was not visited during the season and the following notes were obtained from those familiar with the district. Mr. Elmer Middlecoff continued to operate on Highet Creek. Some ten or twelve miners were working on Haggart Creek and Dublin Gulch. Some work was also done on Duncan and Lightning Creeks. There was a considerable increase in activity on the placer creeks about Mayo Lake. Statistics show that 663·92 ounces of gold were turned in at Mayo during the year up to the end of November.

Other Districts

Small placer operations were being carried on in areas widely scattered over the territory.

A few individual miners were reported to be working on Matson, Thistle, and Canadian Creeks and Klines Gulch on Selwyn River.

In the course of the field work on the Carmacks sheet a brief visit was paid to the placers on Nansen and Victoria Creeks. The district immediately surrounding these creeks was examined and mapped in 1914 by Cairnes*. At the time of the writer's visit five men were working on Nansen Creek and its tributaries and two on Back Creek, a tributary of Victoria Creek. The miners were working in partnerships of two and individually. For the last twenty years small amounts of gold have been recovered from time to time from these placers in this way.

A miner was reported to have discovered some gold on the North Fork of Big Salmon River.

Some staking was reported to have occurred in the vicinity of Sayea and Scurry Creeks on the west side of Liard River.

In the neighbourhood of Livingstone, one or more individual miners were operating on Little Violet, Lake, Summit, and Livingstone Creeks.

Some placer work was also reported to have been done on Geary Creek, a tributary of Teslin River on the left limit near Boswell River.

A few prospectors were also working on placers in Kluane district.

On Squaw Creek on the Yukon side of the provincial boundary the whole valley within the territory has been taken up in a placer lease and was being tested by the Yukon Ventures, Limited. Mr. John Shaller was directing the work and had four men with him. To date not much gold has been recovered from the Yukon side, but the results of the testing have proved encouraging and it is expected that operation is to be continued in the coming season.

Lode Mining

Mayo District

The writer is indebted to Mr. Livingston Wernecke of the Treadwell Yukon Company, Limited, and Mr. A. K. Schellinger of Keno Hill, Limited, and others connected with the district for the following notes.

The Treadwell Yukon Company, Limited, closed down their mill and camp at Wernecke at the end of 1932 and transferred their activities entirely to their properties on Galena Hill. Here this company mined, sorted, and

*Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1914. Nansen and Victoria Creeks, Nisling River, Yukon Territory, Map 151A (issued 1917).

sacked 3,138 tons of high-grade ore, assaying 492·3 ounces of silver to the ton and 30·6 per cent of lead, from the Elsa group, 600 tons of which are still on hand for shipment in 1934. This exhausted the known reserves of high grade in these workings. In October the activities of the company were transferred to the Silver King group, where mining and sorting continued to the end of the year. On this property, another shaft was sunk for 120 feet to facilitate mining the small amount of high-grade ore available.

Mr. E. Bjonnes continued sorting and sacking on the No Cash mineral claim and shipped 37 tons of high-grade ore.

Very little prospecting has been in progress on Keno and the neighbouring hills during this year.

Carmacks District

Work has been discontinued on McDade Hill, but active prospecting has been in progress on Mount Freegold and the ridge extending to the southeast from it. The geology of this prospecting area is given in Summary Reports 1931, Part A, and 1932, Part A II, accompanied by sketch maps of the topography and general features of the geology. The following notes have been gathered from prospectors working in the locality.

Mr. F. Guder, the original staker in this locality, has been prospecting continuously on the west end of Mount Freegold. He has put in a number of pits and trenches and sunk four shafts ranging between 12 and 23 feet deep. These workings have shown up a number of new veins of mineral and some good gold assays have been obtained.

On the south side of Mount Freegold where it slopes down into Seymour Creek Valley, three groups of claims have been prospected. The northwest group is held by Messrs. Langham, Forrest, and Major, and lies west of the Rambler claim shown on the sketch maps published in the reports of 1931 and 1932. A large number of showings on this group have been uncovered by trenches as well as by an adit. Some of the veins are reported to be persistent and two are reported to have been traced for over 1,000 feet. Their widths vary from 10 inches up to 8 or more feet. A number of very good assays have been obtained from this group and some of the results were published in the Dawson Weekly News, October 6, 1933.

Adjoining this group on the southeast Messrs. G. Fairclough and A. Brown hold five claims and fractions, and several good vein showings have been uncovered here giving some very encouraging assays.

Messrs. J. Carpenter and W. Forbes are reported to have staked some claims approximately a mile farther southeast and to have found a large vein carrying fine pyrite and arsenopyrite and gold values.

Geology of Carmacks Map-Area

Though geological work in the Carmacks sheet* has not been completed and the following information may be subject to some modification in the light of further field work, it is thought desirable to publish here some general notes on the geology and to indicate their bearing on the selection of favourable ground for prospecting.

The district embraces the country west of Lewes River and an area between Tatlmain Lake and McGregor Creek on the east side of the river. The district contains large areas of granodiorite and granite and smaller

*Geol. Surv., Canada, Carmacks Sheet, Map 340A, 1936.

areas of syenite and basic intrusives. All these rocks are thought to be related, but to have formed at intervals during a long batholithic period. The areas occupied by these intrusives are separated by belts of older rocks and by areas of younger volcanic rocks that lie unconformably upon them.

The pre-batholithic rocks include two groups, the Yukon group, thought to be mainly Precambrian, and the Older Volcanic group, probably of Mesozoic age. The Yukon group within the district consists of schists, gneisses, quartzites, and limestones. These rocks are well stratified as a rule. Schists varying from nearly pure quartzites to biotite schists form the greater part of the group, though schists and gneisses containing variable quantities of hornblende, feldspar, and quartz also form a large part.

The rocks of the Older Volcanic group along Lewes River are mainly green, basaltic lavas but minor areas are occupied by andesitic volcanics, diorites, and tuffs. In the Dawson Range, porphyritic andesite of greyer green colours predominates and tuffaceous members are more abundant. This group unconformably overlies the Yukon group.

The batholithic intrusives may be divided into three groups, namely, a syenite group, a granodiorite and granite group, and a group of rhyolite and granite porphyry. The rocks of the first-mentioned group form a number of small stocks and bosses following a northwest-trending belt in Dawson Range. They include many varieties of syenite, porphyritic syenite, and hornblende syenite, and show phases grading towards granite. When relationships could be found these syenites are intruded by the granodiorite and granite. With the syenites are grouped small bodies of diorite and gabbro considered as probably belonging to the earlier phases of the batholithic intrusion.

The granodiorite and granite of the second group compose very large bodies. They include both coarse porphyritic types and medium-grained types, and in places along their contacts they pass into massive, foliated varieties.

The rocks of the third group form numerous bodies, mostly small, of rhyolite, granite porphyry, and felsite types. They occur along Dawson Range and scattered over the areas on either side of it. Most of them occur near the borders of the bodies of granodiorite and granite and they cut these rocks.

The Newer Volcanics are divided into the Carmacks volcanics and the Selkirk volcanics. The Carmacks volcanics are chiefly basaltic and andesitic lavas and breccias, but include in some places trachyte and other volcanic types. In a few places shale, sandstone, and conglomerate underlie the volcanics and are exposed at the borders of the areas of these volcanics. The Carmacks volcanics have suffered warping and faulting and were once much more extensive. The Selkirk volcanics consist of black, basaltic lavas and tuffs which in Pleistocene and Recent time were poured out into the valleys in the vicinity of Selkirk and west of McCabe Creek. The areas of Newer Volcanic rocks are regarded as unfavourable for the occurrence of lode deposits, but the remainder of the country presents possibilities as over it the strata are invaded and underlain by great bodies of intrusive rocks. A belt of country that extends from the heads of Victoria and Merritt Creeks northwestward to the head of the east fork of Selwyn River is thought to offer more promise than the rest. Within this belt areas of the rocks of the Yukon and Older Volcanic groups are intruded by bodies of syenite, rhyolite, and granite porphyry, and the whole is bordered on both sides by large areas of granodiorite and granite. In the southeast part of the belt occur the prospects in the vicinity of Mount Freegold and the placers of Nansen Creek district, and in the northwest placers have been found on Selwyn River and its tributaries. The areas of rocks of the Yukon group lying outside the belt are also promising, for none of these areas is remote from intrusives.

Since it is within this belt of country that geological conditions seem to be most favourable for the occurrence of lode deposits, it follows that this particular area may hold the original sources of the gold of placers and, therefore, is worthy of being prospected for placer deposits. It is of interest to note that those tributaries of Nansen and Victoria Creeks on which placer gold has been found drain at their heads areas of rhyolites and granite porphyries, but it should be remembered that the important placer discoveries in Yukon occur in areas of rocks of the Yukon group.

Parts of the district have been subjected to more than one period of glaciation and this important factor should be considered in searching for placers. The features of the last glaciation are still fresh and unmodified and show that in the area covered by the last ice-sheet placers probably have not formed since the retreat of the ice. The area occupied by the last ice-sheet is unfavourable ground for prospecting for placers, not only because of a lack of recent placers there but because any earlier formed placers probably will either have been largely or completely destroyed by the disruptive actions of the ice-sheet or have been buried by the later glacial deposits.

The western limit of the last ice-sheet has not been fully determined. Glacial deposits in the vicinity of Selkirk that lie west of the border of the last ice-sheet present evidence of being older. They have been much modified and partly destroyed.

The Nansen and Victoria Creek placers lie outside the area occupied by the last ice-sheet. Cairnes* in his report on Nansen district mentions the finding of boulder clay in some of the placer workings. It was found this year (1933) that this boulder clay holds completely rotted pebbles and is buried under more recent deposits formed by normal erosive agents. Where the boulder clay was seen, the paystreak rests on it and it is reported that no paystreak occurs on bedrock beneath the boulder clay. The boulder clay in Nansen Creek district is thought to be older than the glacial deposits of Selkirk district because in Nansen Creek area all evidence of glaciation, except that presented by the boulder clay, has been destroyed. The placers of Nansen district formed in a long period of normal erosion following the disappearance of the early ice-sheet. The extent of this early ice-sheet is unknown; but is indicated by the high elevation of the occurrences of boulder clay and by drainage features.

*Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1914.