

GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc. (CANTAB.), LL.D., F.R.S.

REPORT

ON THE

KLONDIKE GOLD FIELDS

BY

R. G. McCONNELL, B.A.



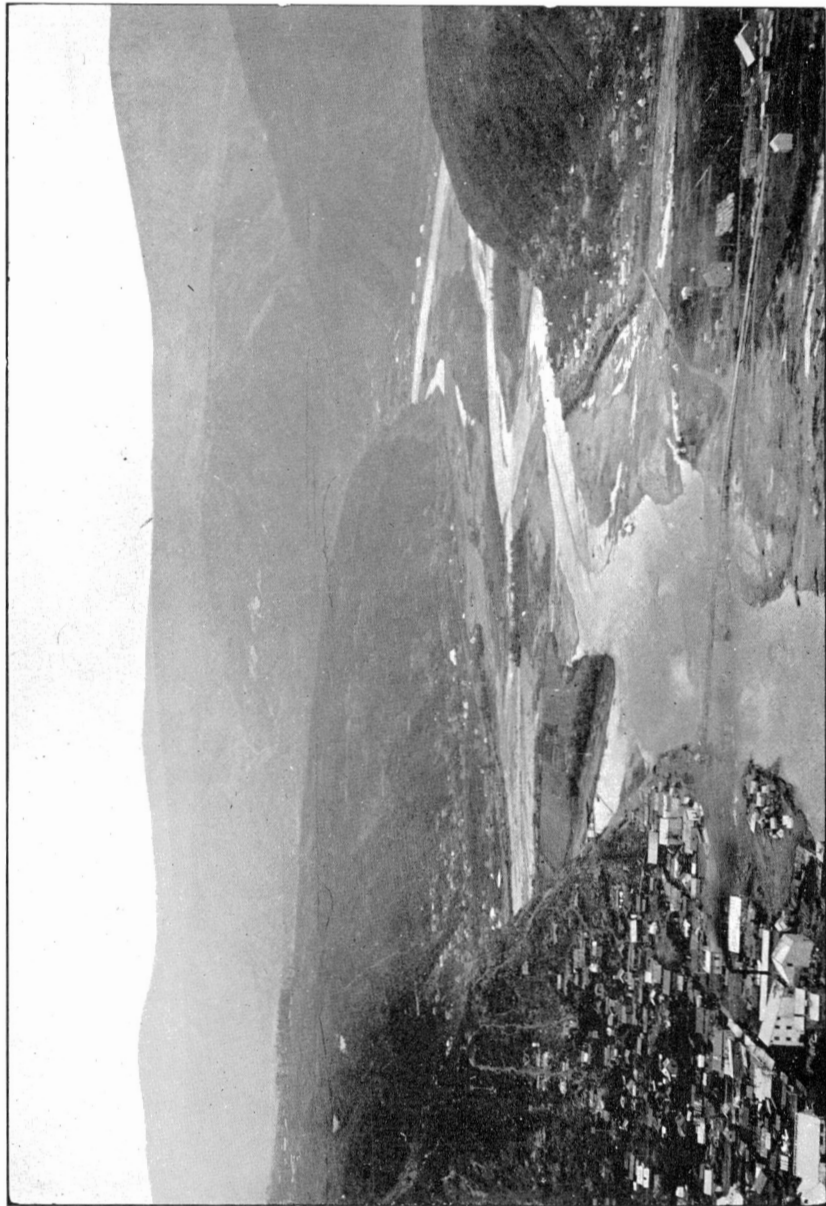
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DAWSON CITY.

[*Frontispiece.*]

Dr. R. BELL, F.R.S., &c., &c.
Acting Director Geological Survey
Ottawa:

SIR,—I beg to submit the following Report on the Klondike Gold Fields based on field work carried on during the season of 1903. A preliminary report on this district was published in 1900, portions of which are incorporated in the present one.

I have the honour to be, Sir,
Your obedient servant,

R. G. McCONNELL.

GEOLOGICAL SURVEY OFFICE,
May 15, 1904.

REPORT

ON THE

KLONDIKE GOLD FIELDS

BY

R. G. McCONNELL, B.A.

HISTORICAL.

An account of the early gold discoveries in the Upper Yukon is ^{Discovery.} 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 Fortymile 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 Sixtymile river in Canadian Territory. The Sixtymile 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

NOTE.—Mr. R. G. McConnell has been engaged in work in the Klondike district in 1898, 1899 and 1900. In 1899 and 1900 he was assisted by Mr. J. F. E. Johnston, who had charge of the topographical work. The topographical map accompanying this report has been constructed by Mr. Johnston from surveys largely made by himself.—R. B.

mark creek B
 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.

Changed conditions.

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.

Area.

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. Plateau character.

Viewed from a distance, the Klondike district has a hilly, even mountainous 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 Dome.

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, Ridges.

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.

Valleys.

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.

Terraces.

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.

Ice.

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.

Frost.

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 Drainage. 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.

Forest trees.

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.

Alteration of rocks.

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.

* 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.

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 Schists. 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 serpentine 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 Intrusives. 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 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.

Altered sedimentary rocks.

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 Fortymile 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 Fortymile series.

Nomenclature.

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 Fortymile 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 mineralogical distinction on which these are based is apparently not persistent.

Composition of Nasina series.

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 Outcrops, intervals along the Yukon valley from a point a few miles below Selkirk down to Fortymile 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.

*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.

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.

Folds and faults.

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 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. Lithology.

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.

Igneous
schists.

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.

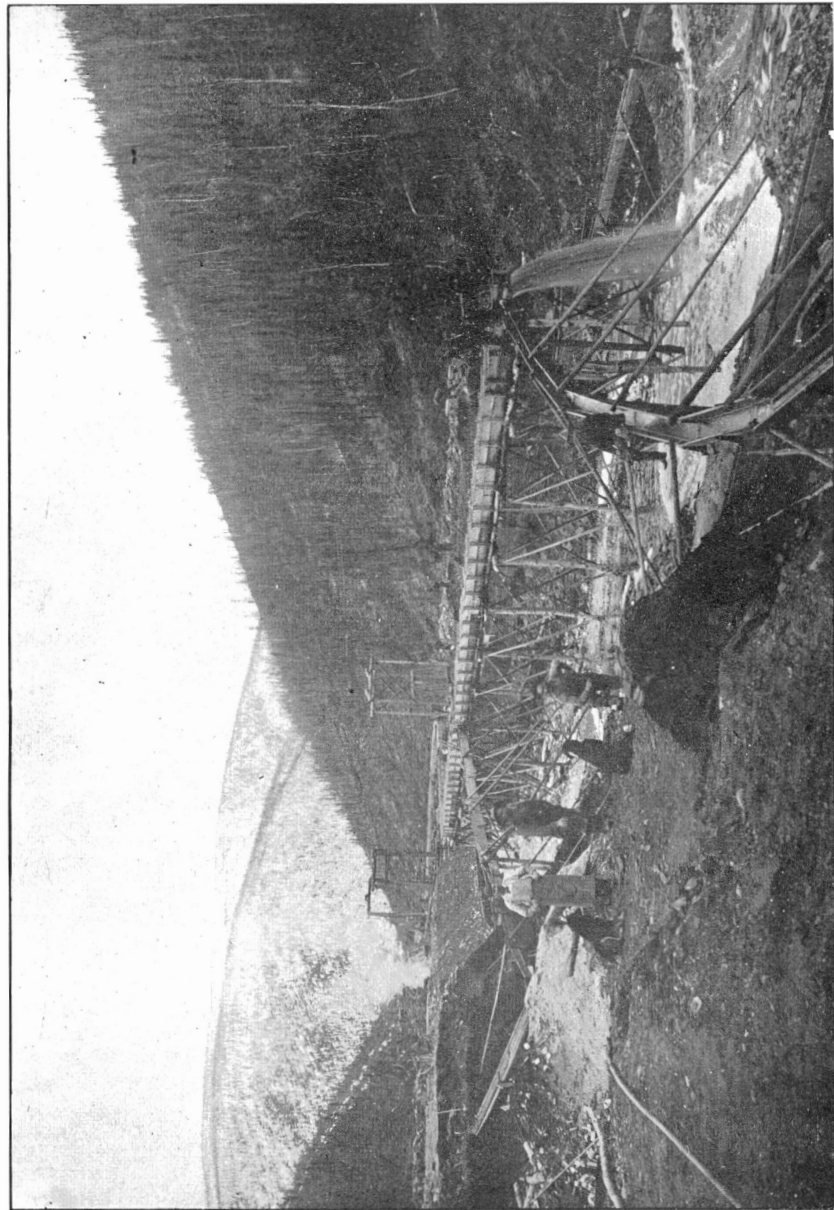
Enclosures.

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.

Occurrences at
other points.

Sericite schists, identical in character with the Klondike schists, occur at various points on 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 Fortymile district the gneisses are followed crossing the strike by



CLAIMS 16-17 "ABOVE," HUNKER.

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. Structure.

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 periphyral 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. Strike.

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 Faults.

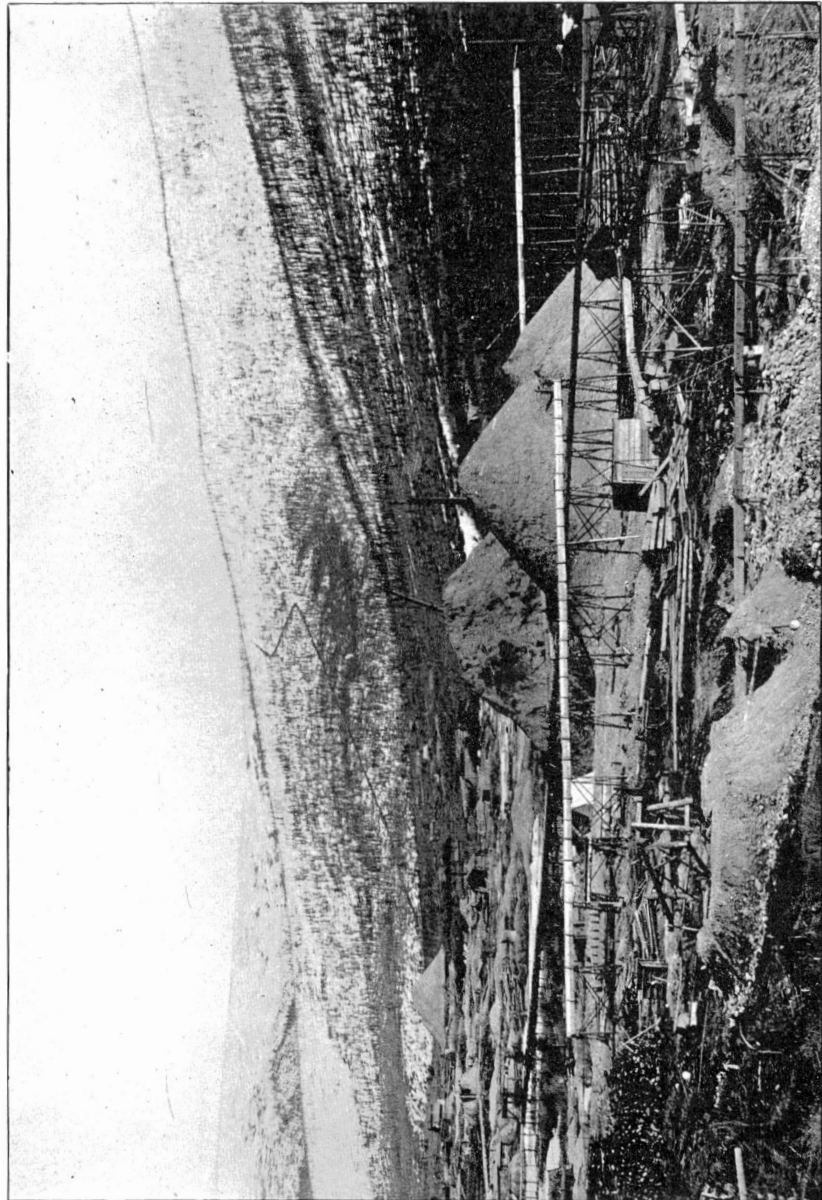
inches to a few feet in extent. A quartz vein, uncovered for sixty feet, in the Violet group of claims south of Eldorado creek, is broken by several faults with small throws, and at one point bends suddenly and follows for a short distance an old cross-fracture plane. The faultings here evidently belong 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.

Granite
gneiss.

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



A PORTION OF DOMINION CREEK, LOOKING DOWN FROM 10 "ABOVE" LOWER DISCOVERY.

ground-mass 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. Microscopical description.

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 the 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.

Secondary
quartz.

"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* and Coleman† and mentioned by Smith‡ and McInnes§, as occurring in the district to the northwest of Lake Superior, while Williams,|| on the south of Lake Superior, gives a very minute recital of the structural features noticed in the altered quartz and granite porphyries of the Menominee and Marquette regions of Michigan. Other occurrences of similar rocks.

"Similar deformed schistose porphyries have not escaped the attention of the European geologists, and Prof. C. E. Weiss** of Berlin in 1884, describes altered quartz porphyries near Thal in Thuringia while Dr. C. Chelius, †† 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 Tuffs. 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."

* Ann. Rep. Geol. Surv. Can. 1887-88, Part I, pp. 85-90F.

† Ann. Rep. Bureau of Mines, Ont., 1894, pp. 84, 87, 88.

‡ Ann. Rep. Geol. Surv. Can. 1890-91. Report G.

§ Ann. Rep. Geol. Surv. Can. 1897. Report H.

|| Bull. U.S.G.S. No. 62, 1890, pp. 148-154.

** Jahrbuch preuss. geol. Landesanstalt für 1883 pp. 213-237 Berlin, 1884.

†† Notizblatt des Vereins für Erdkunde zu Darmstadt, 4, Folge, Heft 5, 1885, p. 29.

Chlorite
schists.

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

Variations.

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.

Character of
diabase.

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.

Relation to
Klondike
schists.

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.

Distribution
of unaltered
sedimentaries.

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 sub-angular 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.

Age.

A small area of Tertiary rocks occurs in the valley of Last Chance creek, just above the junction with Hunker creek. Since their depo-

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

sition, 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 Sixtymile 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.

Area of 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 Twelvemile river S. E. across the Klondike to the Stewart. Between the Stewart and Klondike 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 plateaus 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. Granite area.

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 Diabase areas of dikes.

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.

Andesite
rocks.

Indian River
area.

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.

Yukon River
area.

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 Propylite. 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.

Areas of
quartz por-
phyry.

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 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

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

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 porphyrys, included occasional scales and plates of brown biotite.

SERPENTINES (PERIDOTITES).

Areas of serpentine.

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.

Terraces.

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 that 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.

High level gravels are extensively distributed along Bonanza and Hunker creek 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 plateaus 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.

High level creek gravels.—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. High level
creek gravels.

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. White chan-
nel gravels.

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 stream, and attains its greatest development near their mouths. Yellow
gravels.

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.

Absence of fossils.

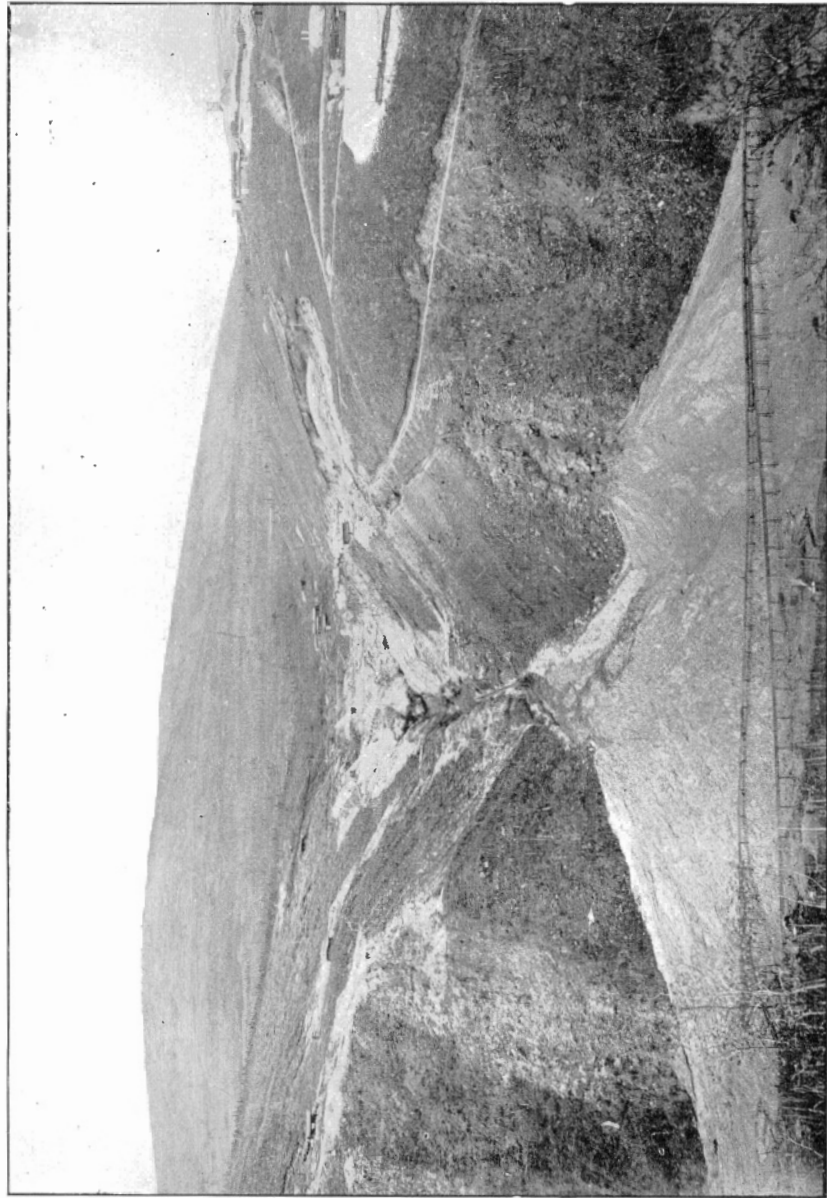
Unlike the creek gravels, the white channel gravels are destitute, or nearly so, of vegetable and animal remains. None were found by the writer and the few reported discoveries of fragments of wood and bone by miners are all open to question.

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.

Origin of white channel gravels.

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.



FOX GULCH WORKINGS, SHOWING BELL-ROCK SLUICE IN CREEK BED OF FOX GULCH; ALSO SHOWING HYDRAULIC GIANT AT WORK ON JOHNSON AND ASKANI CLAIMS.

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.

DESCRIPTION OF CREEKS.

GOLD BEARING CREEKS TRIBUTARY TO THE 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 seventeen 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, 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.

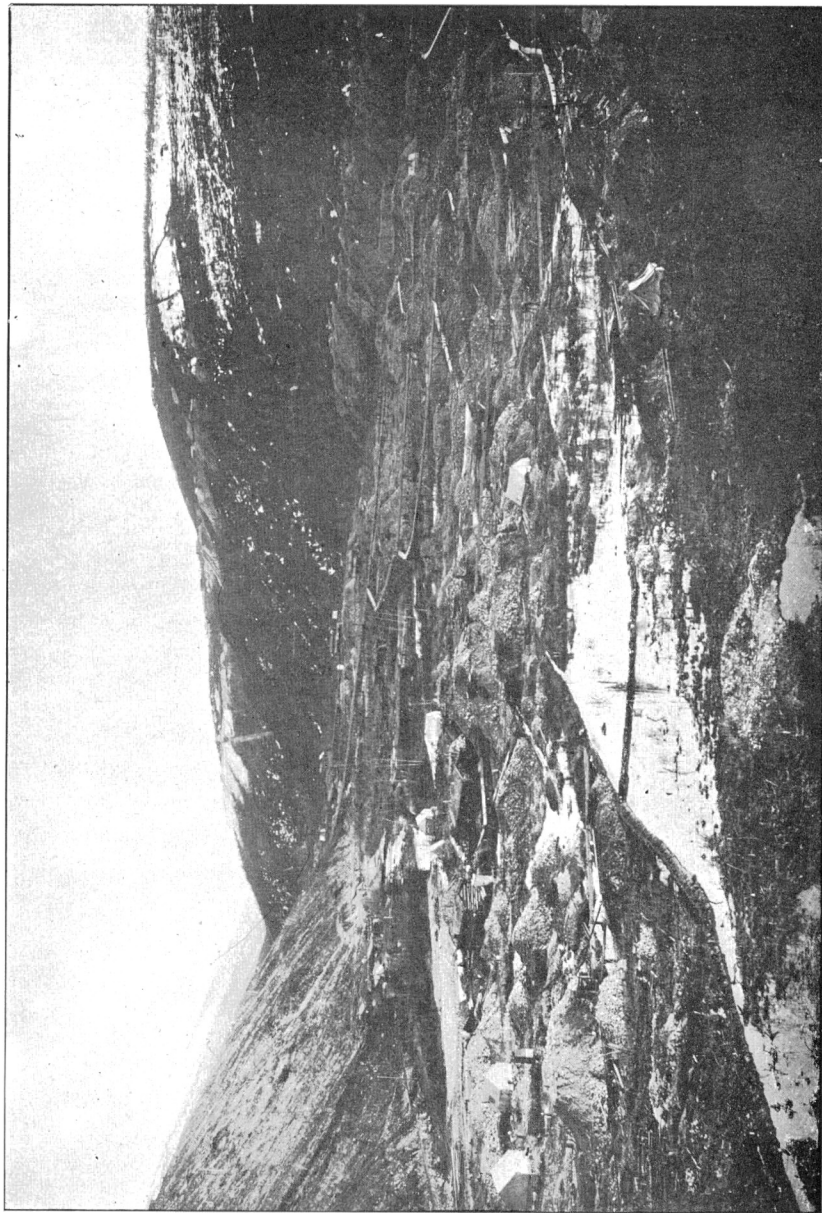
Grades.

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 Carmack 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.

Rocks along valley.

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 29 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.



BIRDSEYE VIEW OF BONANZA, LOOKING UP FROM 46 "BELOW."

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.

Description of
gravels.

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.

Muck.

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

White gravels

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. River gravels.

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. Gold in creek
gravels.

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.

Gold in white
channel
gravels.

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.

Distribution
of gold.

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 hydraulicing operations. Less than half per cent of the total volume of the deposit, estimated at 250,000,000 cubic yards on Bon-

anza 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 flatish 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 include, a larger 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 hillside. 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 rightbank 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 on 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

White channel
gravel.

Gold product-
ion.

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.

Rich claims.

Continuation
of pay.

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.

Character of
gold.

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.

Character of
Hunker creek.

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.

Geology.

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.

Description of
gravels.

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.

Distribution
of white chan-
nel gravels.

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. Producing claim.

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. Value of white channel gravels.

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.

Hunker creek
tributaries.

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.

Character of
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.

Character of
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 the 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.

Geology.

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.

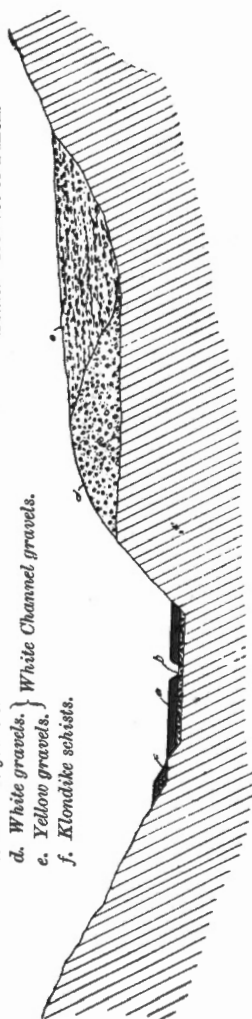
Classification
of gravels.

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

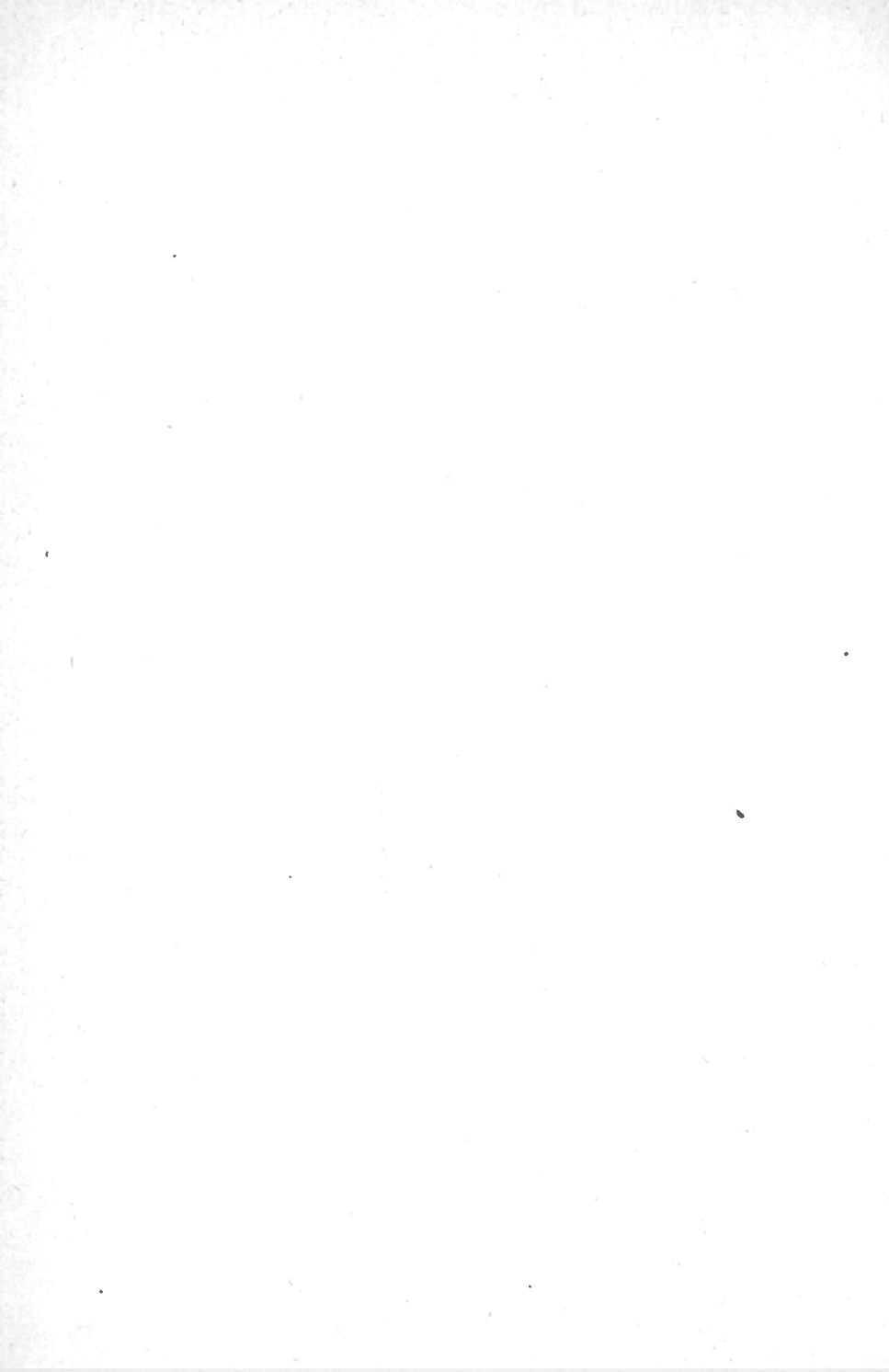
The creek gravels are altogether of local origin and are formed from the rocks outcropping along the valley. They are similar to those in the valleys previously described. Between the two Discoveries, the country rock is unusually soft, and the pebbles are consequently small.

- a. Muck.
- b. Stream gravels.
- c. Terrace gravels.
- d. White gravels. } White Channel gravels.
- e. Yellow gravels. }
- f. Klondike schists.

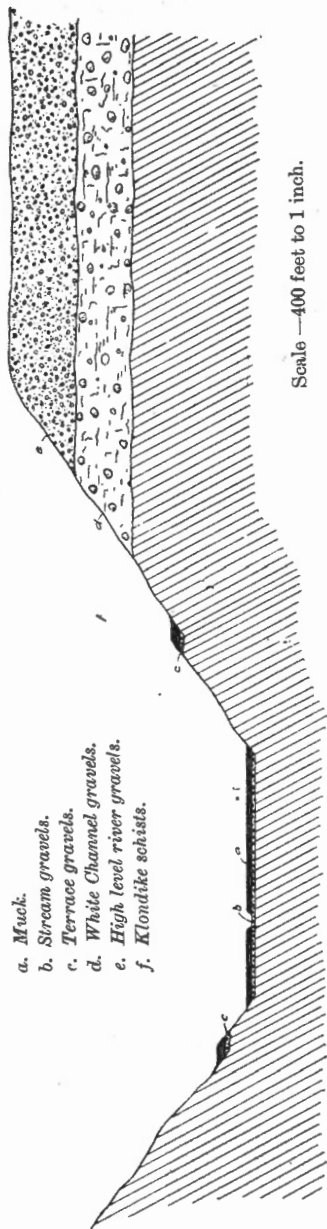
Scale.—400 feet to 1 inch.



GENERALIZED SECTION ACROSS BONANZA VALLEY BELOW ELDERADO FORKS.

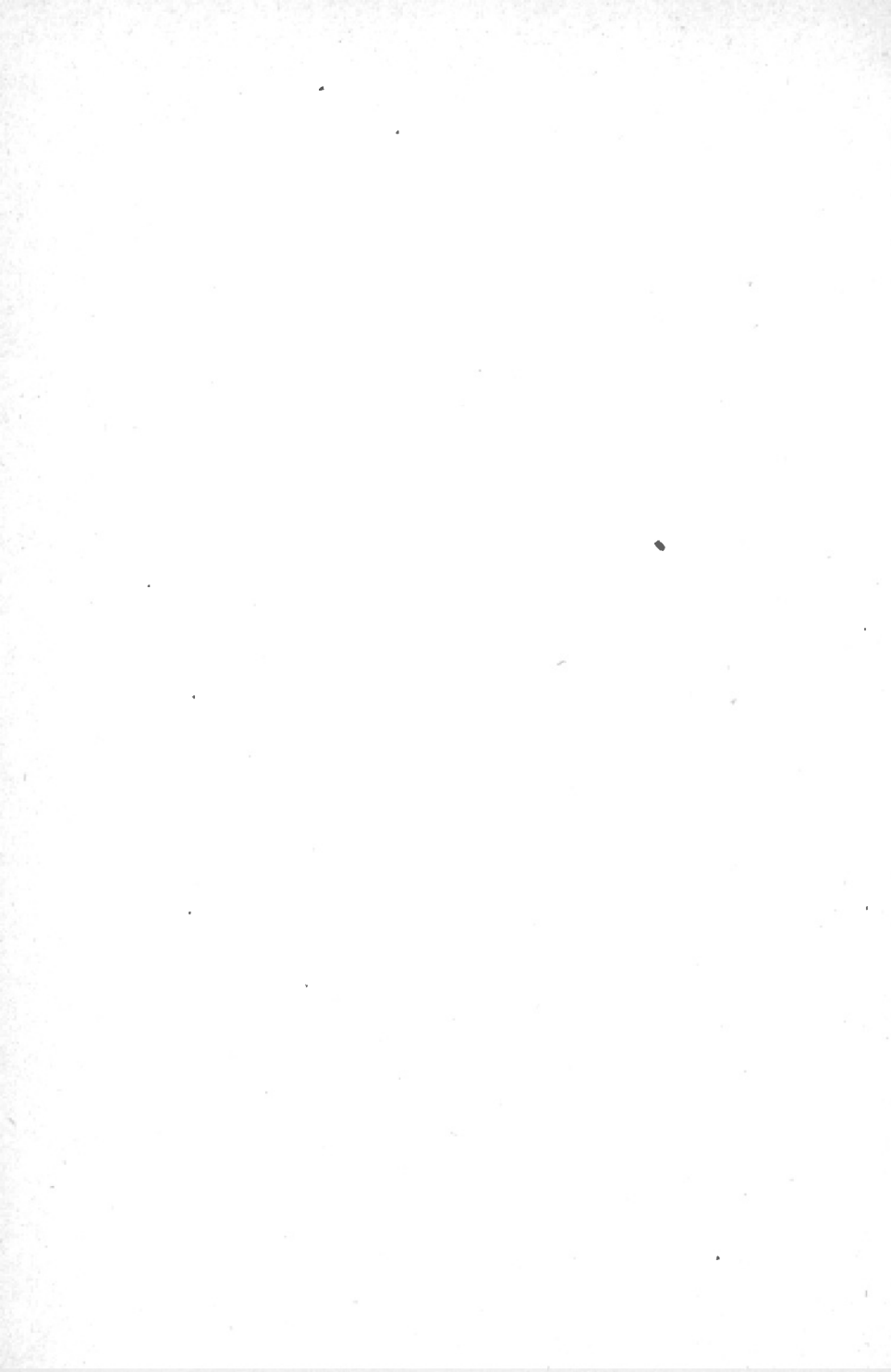


- a. Muck.*
b. Stream gravels.
c. Terrace gravels.
d. White Channel gravels.
e. High level river gravels.
f. Klondike schists.



Scale—400 feet to 1 inch.

GENERALIZED SECTION ACROSS THE LOWER PART OF BONANZA VALLEY.



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.

Origin of
white gravels.

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 production.

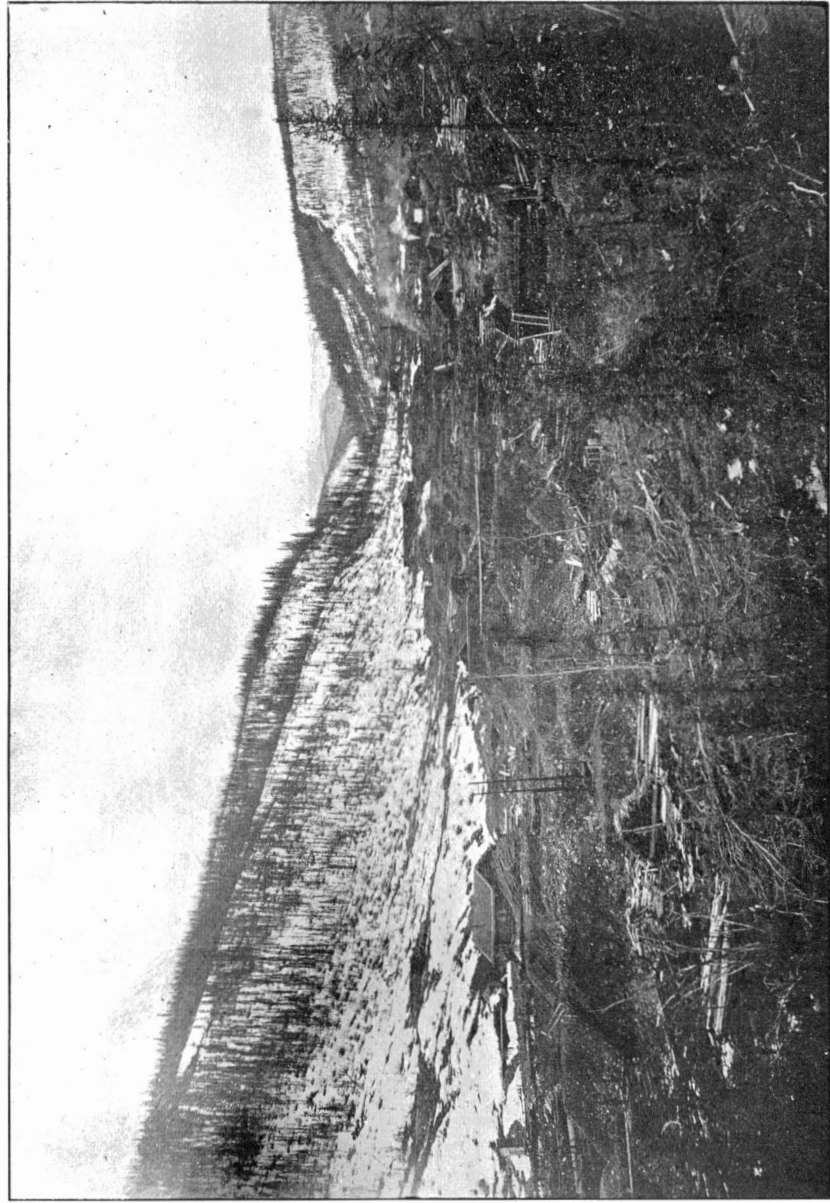
Gold has been found along the greater part of the whole length of the Dominion creek. The pay-streak begins about claim No. 22 above upper Discovery in the narrow gulch part of the valley, and has been followed, with some blank stretches, down almost to the mouth of the creek. The most productive part 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.

Character of gold.

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



BIRDSEYE VIEW OF LAST CHANCE CREEK.

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. Dominion creek tributaries.

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. Character of Gold-run creek.

The valley of Goldrun 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 Gold-run 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.

Productive
portion.

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.

Character of
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.

Valley of
Sulphur creek.

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 100 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-porphry. 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. Geology.

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.

Productive
portion.

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.

Character of
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. Bench gravels.

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. Character of
Eureka creek.

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.

Geology.

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.

Productive
portion.

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

Drifting
method.

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 bed-rock 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 costs 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.

Dredging.

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 Lewis 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 bedrock 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. Steam-shovels

Another attempt, worth mentioning, at cheap mining on the creeks, introduces the hydraulicing 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 hydraulicing, and it serves again to wash the gravels. If this method prove 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. High level
gravels.

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. Scarcity of
water.

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.

Hydraulicig. 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.

Water obtained by pumping.

Water obtained by gravity.

When the water used is obtained by gravity, hydraulicig 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 hydraulicig 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 hydraulicig 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 hydraulicizing 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.

Gold derived
from quartz
veins.

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.

Gold deposited from solution.

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, octohedral 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 abundant.

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.

Character of
quartz veins.

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 enclosing 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.

Age of quartz
veins.

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.

Tin.

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 mammalated 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.

Attempts at 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.

Victoria gulch veins.

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 south-east, 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 vici-

nity, 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 Violet group 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 Claims on
Lepine creek. 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-porphry 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 north of Indian river include large bands of conglomerates, some of which are auriferous, and numerous claims Auriferous
conglom-
erates. 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:—

Gold produc-	1896	300,000
tion of camp.	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

Cause of
dwindling
production.

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

Value of claims.

Exhausted benches.

Unworked portions of Hunker and other creeks.

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 hydraulicing 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 hydraulicing 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 hydraulicing 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 hydraulicing 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. Damming the valleys.

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. Pumping plants.

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 south-east 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 hydraulicizing 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.

