CANADA
DEPARTMENT OF MINES
HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY
W. H. COLLINS, DIRECTOR

Summary Report, 1925, Part A

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OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1926

No. 2113

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SUMMARY REPORT, 1925, PART A

GALENA HILL, MAYO DISTRICT, YUKON

By C. H. Stockwell

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Illustration

Map 2096. Galena hill, Mayo district, Yukon. .... In pocket

INTRODUCTION

The discovery and exploitation in 1914-16 of the Silver King silver-lead deposit on Galena hill, Mayo district, was followed by prospecting which resulted in finding of other silver-lead deposits on neighbouring hills, those on Keno hill,[1] discovered in 1919, being the most important so far found in the Yukon. On Galena hill a considerable amount of staking and prospecting followed, but it was not until 1923 that the float was found which led to the discovery of an ore-body since shown by the mining operations of 1924 and 1925 to be of importance. This deposit, on the Arctic and Mastiff claims, has already produced about 375 tons of high-grade ore, and, at present, is the only productive property on Galena hill. Another property recently shipped a few tons of ore and several prospects have very good indications of the presence of high-grade ore.

The field work upon which this report is based occupied three months during the summer of 1925 and included the topographical and geological mapping, and the investigation of the mineral deposits of Galena hill. In this work J. E. Kania rendered very able assistance. The writer wishes to thank the miners and prospectors of the district, all of whom willingly gave much helpful information and assistance. The writer worked under the supervision of W. E. Cockfield to whom he is grateful for valuable suggestions and criticisms.

Galena hill is 120 miles east of Dawson and 27 miles in a straight line northeast of Mayo on Stewart river, a tributary of Yukon river. During the season of open navigation there is a regular steamship service on Stewart and Yukon rivers between Mayo, Dawson, and Whitehorse. Railway service between Whitehorse and Skagway, on the Pacific coast, is available the year round. In winter, Mayo may be reached by stage from Whitehorse.

A wagon road from Mayo passes along the base of the southeastern slope of Galena hill and continues to the town of Keno a mile farther on. At present an ungraded branch road connects several mineral claims on the upper northwest slope of the hill with the main road, and a somewhat shorter road with a better grade is being constructed for hauling ore to the main road. On the northwest side of the hill an old road, passing through the Silver King property, joins the Mayo road to the southwest.

[1]Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1923, pt. A, pp. 1-21.

TOPOGRAPHY

Galena hill is situated in the dissected Yukon Plateau province, which is mountainous with a relief of 1,500 to 4,000 feet or more. The hill has an elevation at its highest point of a little over 5,000 feet above sea-level and a relief of 2,800 to 3,000 feet above the surrounding valleys. It is about 4½ miles wide and 8 miles long, the longer axis striking northeast. On the northwest it is bounded by the broad, flat-bottomed valley of the south fork of McQuesten river, on the northeast by Crystal creek, on the southeast by Duncan creek, and on the southwest by Williams creek and a low, flat area through which Galena creek flows.

Except for a rock prominence at its highest point, the top of the hill is gently rolling and is grass or brush-covered. These gentle top slopes gradually change to steeper slopes on the sides of the hill, the change in slope being about at timber-line. Still steeper slopes, in part due to glacial erosion, occur on the lower parts of the hill.

Faulting has had an effect on the topography both by determining the location of some of the stream valleys and by causing the formation of escarpments. Examples of stream valleys localized by faulting are those of Galena creek, Brefalt creek, Porcupine gulch, and probably others; the valleys either closely follow, or occur at one side of the faults. An example of a fault scarp is found along a part of the northeastern slope of Porcupine gulch which has been eroded at the base of the scarp and obscures its presence. Other smaller fault escarpments also occur.

Minor irregularities in the topography are due to differences in resistance to erosion of different kinds of rock. Greenstone where surrounded by schist forms prominent knobs and ridges.

GENERAL GEOLOGY

The rocks of Galena hill consist of schist, quartzite, greenstone, and rhyolite. The greenstone, much of which is schistose, and the rhyolite intruded the schist and quartzite along planes of bedding and secondary cleavage. In general the cleavage of the schist and greenstone closely parallels the bedding of the quartzite. On the whole the bedding and cleavage strike slightly north of east [1] except on the part of the hill east of its highest point where the strike is slightly south of east; in detail the strikes vary as a rule between 35 degrees north and 35 degrees south of east. The average dip is about 30 degrees southerly, but the angle varies, for the most part, between 20 degrees and 40 degrees and is even as high as 75 degrees in the vicinity of faults.

The quartzites and schists form three, lithologically distinct stratigraphical units: a lower schist member; a middle quartzite member; and an upper schist member. The three units apparently are conformable and within the map-area have a monoclinal dip.

The *lower schist member* occurs along the lower part of the northern, and part of the northwestern, slopes of the hill. It consists mainly of grey, black, and green schists containing variable amounts of quartz, mica, graphite, and chlorite. Thin beds of quartzite are in places interbedded with the schist. A light green, quartz-mica-chlorite schist is characteristic of the upper part of this schist member.

[1] All directions referred to in this report are astronomic.

The *middle quartzite member* outcrops along the northwest slope, the summit at the northeast end, and the northeast slope of the hill. It consists dominantly of a massive, grey and white quartzite which in places contains a considerable amount of mica and has a gneissoid appearance. Under the microscope the quartz is seen to be recrystallized and, in addition to the mica, minor amounts of graphite, epidote, and pyrite are present in some cases. Minor amounts of quartz-mica schist and quartz-graphite schist occur interbedded with the quartzite. Locally the quartzite is calcareous. In its upper part the quartzite is for the most part less massive and has a banded appearance; it contains a considerable amount of mica and graphite. Interbedded with this banded quartzite is much quartz-graphite schist.

The *upper schist member* occupies a large area on the southern half of the hill. It consists largely of grey and yellow quartz-mica schists. Quartz-graphite schist and quartzite are quite abundant locally and minor amounts of crystalline limestone and chlorite schist also occur. The lower part is generally characterized by a quartz-mica schist containing rounded particles of quartz readily visible to the naked eye. The microscope shows in addition a few rounded grains of orthoclase, acid plagioclase, and rock fragments.

The middle quartzite, lower schist, and upper schist are correlated with a part of the Nasina series of Klondike district described by McConnell [1] and referred by Cairnes [2] to the Precambrian. The strata on Galena hill are believed to be largely of sedimentary origin.

Greenstone intrudes the quartzite and schists. It occurs chiefly in the lower schist member, and to a less extent in the quartzite, but is almost entirely absent from the upper schist. In the lower schist area it forms irregular, discontinuous masses elongated in a direction approximately parallel to the schistosity. In the quartzite it has been intruded along bedding planes and has formed bodies of fairly uniform character. The greenstone is much altered. It probably represents andesite and related rock types. It contains hornblende, altered feldspar, and a small amount of original quartz and titanite; alteration products include quartz, chlorite, and calcite. Locally it contains much biotite and a considerable amount of quartz. The greenstone is both massive and schistose. It is younger than the schists and quartzite, and is probably earlier than the rhyolite.

The rhyolite was intruded as a thin sill along parts of the contact between the quartzite and the upper schist member. It is a fine-grained, non-schistose rock composed of quartz, acid plagioclase, altered orthoclase, mica, calcite, and a little chlorite. The rhyolite is probably younger than the greenstone, for, although its relation to the greenstone was not determined on Galena hill, similar acid rocks cut greenstone on Keno hill.[3] The rhyolite may be an offshoot from a granite of, probably, Jurassic or Cretaceous, but possibly Tertiary, age. Although the granite was not found on Galena hill it outcrops at several localities in Mayo district and probably underlies much of the area.

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[1]McConnell, R. G.: "Report on the Klondike Gold Fields"; Geol. Surv., Canada, Ann. Rept., vol. XIV, pt. B, pp. 12-15 (1901).

[2]Cairnes, D. D.: "The Yukon-Alaska International Boundary"; Geol. Surv., Canada, Mem. 67, pp. 38-44 (1914).

[3]Cockfield, W. E.: "Silver-lead Deposits of the Keno Hill Area, Mayo District, Yukon"; Geol. Surv., Canada, Sum. Rept. 1920, pt. A.

The quartzite and probably at least the major part of the schist were originally sediments which with the greenstone bodies have been folded to their present attitude and metamorphosed to quartzite and schist. The folding has resulted in general dips to the south and the local formation of crenulations and drag-folds in beds of limestone and impure quartzite. The axial planes of the drag-folds strike northeast and dip southeast, indicating that during the folding the upper beds moved northwest relative to the lower beds.

All the consolidated rocks have been faulted. Since the faults are closely related to the mineral deposits, they are described under the heading of economic geology. Many joints are present, particularly in the quartzite, greenstone, and rhyolite.

Glacial deposits are thick on parts of the lower slopes, but are generally thin on the upper slopes and top of the hill. The ice moved southwesterly and on the top of the hill it scattered quartzite boulders over the schist to the southwest. The quartzite boulders are abundant near the contact between the quartzite and upper schist and gradually become less abundant to the southwest. Most of the bedrock is covered by rock float, talus, vegetation, and glacial deposits, but the character of the underlying rock may in many cases be judged by the nature of the float. Rock in place is well exposed in deep gulches, but outcrops are as a rule scarce elsewhere; quartzite and greenstone are better exposed than schist.

ECONOMIC GEOLOGY

The mineral deposits of Galena hill are fissure veins in which the ore occurs chiefly in shoots. The veins follow faults which, with a few exceptions, strike northeasterly and dip steeply to the southeast. Other northeasterly-striking faults, which are not known to be mineralized but warrant prospecting, have also been mapped. Northwest faults occur also, some of which are apparently later than and offset the northeast faults; these later faults are not known to be mineralized.

The faults as a rule are not easily recognized in the field. Fault-planes are rarely exposed except in artificial excavations. Observed fault-planes, if not too much altered by weathering, are slickensided surfaces with steeply dipping striæ. Where not exposed, faults are inferred to be present where formations are offset along their strike, such evidence being supported in many places by an abrupt difference in strike or dip of bedding planes on opposite sides of the fault or by the presence of an escarpment along the fault.

The faults probably are not as simple as indicated on the map, and some that are shown as single faults may actually be zones of faulting complicated by cross-faults. Many faults in addition to those mapped no doubt also occur.

The following minerals occur in the deposits:

Native elements	silver, gold
Sulphides	galena, sphalerite, pyrite, arsenopyrite, chalcopyrite, marcasite, pyrrhotite, stibnite
Sulpho-salts	freibergite, pyrargyrite
Oxides	quartz, chert, limonite, manganese oxide
Carbonates	siderite, ankerite, calcite, cerussite, malachite, azurite
Silicates	white mica

The veins have been classified on a mineralogical basis into four groups, as shown in Table I. The classification of any particular deposit is tentative, for further development work will undoubtedly lead to more knowledge of the character of the veins. There are no sharp dividing lines between the different groups of deposits, but taken as a whole each group has certain fairly definite characteristics.

TABLE I

*Summary of Mineralogy, Strikes, and Dips of the Known Veins on Galena hill: *, surface trace; X, of major importance; x, of minor importance*

		Native elements		Sulphides								Sulpho-salts		Oxides				Carbonates						Silicates				
Group	Name of property	Silver	Gold	Galena	Sphalerite	Pyrite	Arsenopyrite	Chalcopyrite	Marcasite	Pyrrhotite	Stibnite	Freibergite	Pyrargyrite	Quartz	Chert	Manganese oxide	Limonite	Siderite	Ankerite	Calcite	Cerussite	Malachite	Azurite	White mica	Silver values	Gold values	Strike of vein	Dip of vein
I	Arctic and Mastiff			X		x						x		x		X	X	X			X				X		N. 12° E. N. 48° E. N. 27° E.	67° SE.
	Ruby Fraction			X		x						?				X	X	X			X				X		N. 55° E.	67° SE.
	Coral and Wigwam (main vein)	x		X		x						X		x		X	X	X			X				X		N. 53° E.	70° SE.
	Elsa			X		x		x				X		x		X	X	X			X	x	x		X		N. 45° E.	70° NW.
	Dragon (Main vein)			X								X		x		X	X	X			X				X		N. 16° E.	66° SE.
	Hector			x												X	X	?			X				X		N. 48° E.	65° SE.
	Dixie (siderite float)					x										X	X	X									....	....
II	Silver King vein			X	X	X		x	x				X	X	x	X	x	X	x		X				X	x	N. 68° E.	55°-80°SE.
	Rico					x								x		X	x	?	x								NE.	SE.
	Bluebird			X	X	x								x		x	x		X	x	x				X		N. 25° E.	62° SE.
	Tin Can			x	x	x								x		x	x	x	X	x							N. 50° E.	SE.
	Eagle			X	x	X								X			x	x				x					N. 50° E.	SE.
III	Jupiter		x		x	X	X							X			x		X	x				x	x	x	N. 53° E.	80° SE.
	Betty			X	X		x			x				X			x			X	x				x		N. 58° E.	SE.
	Crystal King			x	x	x	X							X											x	x	N. 74° W.	60° NE.
	Dragon (cross vein)			x		X	X							X												x	N. 82° W*	....
	Dixie (quartz vein)						x							X													E.-W.	40° S.
IV	Coral and Wigwam (stibnite vein)										X			X											x		....	....

(I) The veins of group No. 1 may be called siderite-galena-freibergite veins. Manganiferous siderite is by far the most important gangue mineral; galena and freibergite are the most important ore minerals. The chief minerals formed by weathering of the gangue and ore minerals are cerussite, limonite, and manganese oxide, the last causing conspicuous blackening in the oxide zone. Quartz and pyrite are present as a rule, but only in very small quantity. Chalcopyrite, malachite, and azurite were found only in small amounts in one deposit. Native silver is reported to have been found near the surface of one deposit. Silver values are mostly high, although not always in sufficient amount to make mining profitable. Gold values are absent or unimportant.

The vein at the only mine in operation on the hill at present and those of most of the encouraging prospects have this type of mineralization.

(II) A considerable variety of deposits are included in group No. II. The predominant gangue mineral is either quartz or ankerite; calcite is present in a few places and siderite is either subordinate or absent. Although the ankerite generally carries manganese, the black manganese oxide, so characteristic of the oxide zone of the veins of group I, is less conspicuous in most, although not all, of these deposits. Both galena and sphalerite were noted in all except one deposit; pyrite is always present and occurs in important amount in some cases; limonite, cerussite, chalcopyrite, and malachite are also present. Silver values are important in some of the deposits.

One deposit, the Silver King vein, mined chiefly during the years 1914-16, does not closely resemble any other known deposit on the hill in that it contains an important amount of ruby silver, smaller amounts of marcasite and chert, and was a rich silver-lead deposit in a gangue consisting mainly of quartz. Small values in gold were also present.

The Silver King vein has in the past been an important producer and some of the other deposits in this group are encouraging prospects.

(III) The veins of group No. III may be called quartz-arsenopyrite veins. Quartz is the chief gangue mineral, but ankerite, calcite, and a minor amount of white mica are present in some veins. Arsenopyrite is characteristic; pyrite, galena, and sphalerite are present in most cases; pyrrhotite occurs in one deposit and a speck of native gold was found in another. Cerussite and limonite are present as alteration products. The veins as a rule contain small values in both gold and silver.

Deposits of this type on Galena hill have not yet shown promise of being of economic importance.

(IV) Group No. IV is represented by one unimportant quartz-stibnite deposit said to carry low silver values.

The age of the faults of group III (the quartz-arsenopyrite veins) on Galena hill has not been determined, but on Keno hill, which lies to the northeast, it has been determined that veins mineralized with quartz, arsenopyrite, and pyrite are older than veins mineralized chiefly with siderite, freibergite, galena, and sphalerite.[1] The general similarity in the geology of the two hills suggests that on Galena hill the veins of group III may be older than those of groups I and II. The age relation between the veins of groups I and II is not known. The northwest faults not known to

[1]Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1923, pt. A, p. 4.

be mineralized are believed to be the youngest faults, for they apparently offset the veins of the above groups.

The strikes of the veins of the different groups vary between the limits shown below. The limiting directions of the surface traces of northwest faults not known to be mineralized are included for comparison; the true strikes of these are not known, but they probably approximate the direction of the trace.

Surface traces of northwest faults not known to be mineralized	N. 72° W. to N. 21° W.
Veins of group I	N. 12° E. to N. 55° E.
Veins of group II	N. 25° E. to N. 68° E.
Veins of group III[1]	N. 53° E. to S. 74° E.

There is an overlapping of the strikes of the veins of the different groups, as classified on a mineralogical basis, and a marked variation in the strike of the veins of any one group. Regardless of this overlapping and variation the strikes of veins now known are on the whole different in different groups. Those of group III, probably the oldest, approach most closely the general strike of the rocks, which is slightly north of east; those of groups I and II, which are probably intermediate in age, strike more northeasterly; and the youngest faults, which are not known to be mineralized, strike northwesterly.

The bedrock strikes slightly north of east and dips southerly less steeply than the veins. All the veins of group I occur in the quartzite; some of those of groups II and III occur in the quartzite and the rest in the lower schist and intruded greenstone. No veins are known to occur in the upper schist.

The veins cut the greenstone and are probably closely related in age to the rhyolite. It is thought that both the material of the veins and the rhyolite had their origin in a granite mass which is believed to underlie much of the district. Granite occurs at the surface to the east, northeast, northwest, and southwest of Galena hill at distances of 18, 10, 14, and 25 miles respectively, and at other places in Mayo district. The granite is probably contemporaneous with the Coast Range intrusives, which in the Yukon may range from Jurassic to well into Cretaceous time.[2] The veins were formed during the later stages of the consolidation of the granite.

In prospecting for silver-lead veins it has been found that float of black manganese oxide or galena is a valuable indication of the presence of a vein. The prospector follows the float up hill and looks for a vein near the upper limit of the float under the superficial covering, which is removed by means of open-cutting or ground-sluicing. It should be borne in mind that the ice-sheet which moved southwesterly may have distributed some float up hill from the veins; however, this has not been an important factor and most of the float is found on the slope below the vein. If the float is fairly abundant and occurs at or near the surface it is likely to be derived by down-slope creep from the veins; if it occurs in scattered masses in the drift it is likely to have been transported by the ice-sheet. Prospecting is difficult because of the frozen nature of the ground. Ground-sluicing with snow water, in the spring, is extensively used for removing the overburden. The quartzite and large greenstone areas appear to be the most favourable for the occurrence of wide, persistent veins.

[1]The strikes of two non-persistent stringers have been omitted.
[2]Cairnes, D. D.: Geol. Surv., Canada, Supplement to Mem. 31 (from Sum. Rept. 1915), p. 42.

DESCRIPTION OF PROPERTIES

ARCTIC AND MASTIFF CLAIMS

These claims are at present the most important on the hill and during the summer of 1925 were the only ones being mined. They are situated high on the northwestern slope of Galena hill near the head of Star creek. The owners are C. R. Settlemier, C. H. Bermingham, S. M. Dorr, and A. Stoner.

The claims were staked in 1921. In 1923 float was found which led to the discovery of the present mine. In the spring of 1924, 26 tons of ore was shipped and in September, 1925, about 350 tons of ore was sacked ready for shipping the following winter. A much larger tonnage may be expected in the future. The ore is hand-sorted before sacking for shipment. The owners state that the sacked material averages approximately $200 to the ton, and carries about 62 per cent lead and 150 ounces or more of silver to the ton.

A shaft, inclined 67 degrees to the southeast, has been sunk to a vertical depth of 46 feet and a drift run for 100 feet along a vein. The floor of the drift is 38 feet below the collar of the shaft. Other workings consist of a prospect shaft and about twenty-five open-cuts.

A small amount of ore was found near the surface in sinking the main shaft, in the prospect shaft, and in some of the open-cuts, but the main ore-body was opened up along the drift. The drift is along what appears to be the top of a tabular ore-shoot, the limits of which are as yet unknown. The part mined out was at least 90 feet long and averaged at least 5 feet in width, but in some places was as much as 9 feet wide. The depth is unknown. Approximately 3,500 cubic feet of the material mined, which is highly porous, yielded after sorting, 350 tons, a ratio of 10 cubic feet of ore in place to one ton of sorted ore. The hanging-wall of the ore-shoot as a rule dips 67 degrees southeast; the foot-wall is at a steeper angle. The strike is variable, due to an abrupt difference in trend in the central part, the northeast half striking north 12 degrees east and the southwest half striking north 48 degrees east. The country rock is quartzite with some mica and graphite schist, the schist apparently being more abundant on the hanging-wall.

The minerals in the vein are galena, cerussite, and freibergite in a gangue of limonite, manganese oxide, siderite, and a very small amount of quartz and pyrite. The galena, which contains sparsely distributed blebs of freibergite, occurs in irregular masses, but more typically in bands parallel to the strike and dip of the ore-shoot. Due to movement along the vein the galena is generally gneissoid, particularly near the hanging-wall. It is coarse-grained, fine-grained, and "steel"; the latter variety occurs as a rule in small amounts close to the hanging-wall and is said to contain higher silver values. The most abundant primary minerals of the deposit are galena and manganiferous siderite. Due to oxidation, hydration, and leaching by surface waters the siderite has been almost completely altered to limonite and manganese oxide, with the development of much pore space and many small cavities. The galena has been much more resistant and is generally fresh, although on exposed surfaces it is altered to earthy cerussite. Cerussite also occurs as small crystals loosely adhering to the walls of cavities in limonite, manganese oxide, and galena. During the summer, waters percolate freely through certain channels in the deposit, but some of the cavities are filled with ice.

The vein probably has been offset by a northwest fault. The part of the vein described above appears to lie on the northeast side of the fault and to be offset to the southeast relative to the part of the vein on the southwest side of the fault. This latter part of the vein, which strikes north 27 degrees east and dips steeply to the southeast, has been exposed by a prospect shaft, mentioned above, and open-cuts. The material on the dumps indicates that the vein is mineralized for a length of 300 feet from the fault with limonite, manganese oxide, and a small amount of quartz and pyrite; a little galena and cerussite were also found.

RUBY FRACTION

This property, a small fraction owned by E. Bjonnes, is situated on the northeast side of the Mastiff claim.

A vein, 1½ feet wide, striking north 55 degrees east and dipping 67 degrees southeast, was prospected during the summer of 1925 by means of two open-cuts. The country rock is mainly quartzite with some mica and graphite schist. The vein is mineralized with siderite, galena, a small amount of pyrite, and probably freibergite. Alteration products are limonite, manganese oxide, and cerussite. According to information supplied by the owner, the galena carries from 250 to 385 ounces of silver to the ton and earthy cerussite carries as high as 700 ounces of silver to the ton.

CORAL AND WIGWAM CLAIMS

This property, part of a large block of claims owned by R. Fisher and Dr. W. E. Thompson, is situated at the head of Porcupine gulch on the northwest slope of Galena hill. The claims were staked in 1921, but the main work on the property was done in 1924. The owners state that 7 or 8 tons of ore, assaying 258 ounces of silver to the ton and 61 per cent lead, were shipped. No mining was done on the property during the summer of 1925.

The workings consist of a few open-cuts and three shafts along the strike of a vein. The centre shaft is 26 feet deep and from the bottom a drift has been run a short distance northeast along the vein; from near the end of the drift a short crosscut was driven southeast. The other shafts were filled with water at the time of the writer's visits. On adjoining claims belonging to the same owners, three ditches, two of which are shown on the map, were dug during the summer of 1925 in preparation for ground-sluicing in the following spring.

The centre shaft, drift, and crosscut are in a shear-zone striking north 53 degrees east and dipping 65 to 75 degrees southeast. The foot-wall is mica and graphite schist and the hanging-wall is chiefly quartzite with some schist. Mineralization is irregular and occurs chiefly near the foot-wall of the shear zone. The primary minerals are galena, associated with a considerable amount of freibergite, in a gangue of siderite and minor quantities of quartz and pyrite. Alteration products observed are limonite, manganese oxide, and cerussite. It is reported that native silver occurred near the surface at the shaft.

Similar gangue minerals and their alteration products were observed on the dumps of the other two shafts, and in addition to these minerals a little galena was seen at the northeast shaft.

Just northwest of the latter shaft brecciated quartzite is mineralized with quartz and stibnite. The deposit is said to carry only low values in silver.

ELSA CLAIM

This property, owned by C. Brefalt and D. Tolmie, is situated low down on the south side of Porcupine gulch. In the spring of 1925 a vein was exposed by means of ground-sluicing and was further prospected by an open-cut.

The country rock is quartzite with some graphite schist. The mineralization occurs in a fault which strikes north 45 degrees east and where exposed in the open-cut dips 70 degrees northwest. At this point the walls are poorly defined, but the vein may be as much as 7 feet wide. The primary minerals present are siderite, galena, which is partly gneissoid and partly undisturbed, freibergite, and minor quantities of quartz, pyrite, and chalcopyrite; alteration products include limonite, manganese oxide, cerussite, malachite, and azurite. The vein material occurs in part as a cement of quartzite breccia. The owners stated that samples of galena from the deposit assayed from 69 to 82 per cent lead and from 150 to 446 ounces of silver to the ton and that a sample of siderite and freibergite assayed 1,480 ounces of silver to the ton.

The fault probably extends for a considerable distance northeast and southwest from this open-cut. The presence of float vein material on the crest of the northern slope of Porcupine creek and in line with the strike of the vein indicates that the fault is mineralized at this point also.

DRAGON CLAIM

This property, owned by O. Miller, is situated on the northern slope of the hill about a mile northeast of the highest point. During the past four years a great deal of work has been done on the property. A vein has been prospected along its strike for a distance of 500 feet by means of three shafts, 20, 24, and 42 feet deep respectively, five open-cuts, and two sluices. Many open-cuts and two sluices have also been made to the northeast of the main workings.

The vein, which is reported to be from 5 to 7 feet or more in width, strikes north 16 degrees east and dips 66 degrees southeast. The hanging-wall is quartzite and the foot-wall in most places black schist. The minerals in the vein are siderite, limonite, manganese oxide, galena, cerussite, freibergite, and a little quartz. The ore minerals carry high values in silver, but are only sparsely distributed through the siderite, which is the main constituent of the vein.

Near the northeast end of the vein the siderite ends abruptly and the mineralization is quartz, arsenopyrite, galena, and pyrite. Assays are said to show some gold values. It is assumed that this mineralization is in a cross-fault, the surface trace of which strikes north 82 degrees west. It is not known whether the fault is older or younger than the siderite vein.

To the northeast of this cross-fault and along the strike of the siderite vein there is apparently a brecciated quartz vein, but no siderite has been found. In a ground-sluice 950 feet northeast of the end of the siderite vein some galena float is present.

HECTOR CLAIM

This property, owned by C. Sinyard and M. S. McCown, is situated just west of the highest part of Galena hill.

A vein, which strikes north 48 degrees east and dips 65 degrees southeast, was exposed during the summer of 1925 by means of two open-cuts. The country rock is quartzite, graphite schist, and greenstone, the last being exposed in one of the open-cuts on the hanging-wall of the vein. The vein, where exposed, is from 4 feet 3 inches to 5 feet wide. The material filling the vein is mostly limonite and manganese oxide which are probably alteration products of siderite. Cerussite and a little galena are also present. According to the owners the silver values are as high as 312 ounces to the ton, are carried chiefly in cerussite, and are as a rule highest near the hanging-wall. Part of the vein filling, particularly along the footwall, is quartzite breccia cemented by siderite. A band of soft quartz flour occurs along the hanging-wall.

DIXIE CLAIM

This claim, owned by J. V. Sullivan, is situated on the northwestern slope of Galena hill; the workings are at an elevation of about 3,900 feet and are 2,000 feet northeast of Porcupine gulch.

The country rock is quartzite intruded by a sill of greenstone. In two open-cuts in quartzite 300 feet north of the greenstone some siderite float has been found. The siderite contains a little pyrite and is partly altered to limonite and manganese oxide.

In an open-cut near the greenstone a quartz vein sparsely mineralized with arsenopyrite is exposed. It strikes roughly east-west and dips about 40 degrees south.

A ditch has been dug in preparation for ground-sluicing in the spring of 1926.

SILVER KING, MABEL, ADAM, AND WEBFOOT CLAIMS

The Silver King property is situated on Galena creek west of Galena Hill proper. Although it is not being mined at present it was a producer of importance, particularly during the years 1915 and 1916. Over 2,500 tons of high-grade ore has been shipped.

The property was examined in 1915 by D. D. Cairnes who gives its early history as follows.[1] "The Galena Creek vein is believed to have been discovered and staked by H. W. McWhorter and partner about the year 1906, but the claim was afterwards allowed to lapse. The deposit was relocated in 1912 or 1913 by Mr. McWhorter who gave a lay on the ground to Jack Alverson and Grant Hoffman. These layers did the first

[1]Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1915, pp. 27-29.

real development on the property, and proved it to be of importance. They shipped 59 tons of ore to the smelter at Trail, B.C., the smelter returns for which amounted to $269 a ton, in gold, silver, and lead, the gold being very low, but the lead amounting to 45 per cent. In the spring of 1914 the property was acquired by Thomas P. Aitken and Henry Munroe, Mr. Aitken being the principal owner. During the winter of 1914-15 these owners shipped 1,180 tons of ore to San Francisco. The smelter returns for this shipment, according to a statement kindly furnished by Mr. Aitken, included $3 a ton in gold, and for about half of the ore, 39 per cent lead and 280 ounces of silver, and for the other half 23 per cent lead and 260 ounces of silver per ton." Mr. Aitken continued the mining until the spring of 1916. Later an option was secured by E. J. Ives and F. Manley who did some drilling on the property.

The vein has a known length of 2,400 feet, strikes north 68 degrees east, and dips steeply southeast. The country rock on the foot-wall side of the vein is massive quartzite and on the hanging-wall side is interbedded schist and quartzite. According to information kindly supplied by Mr. Alverson, the ore mined from the Silver King property occurred mainly in a shoot which pitched northeast along the vein. The shoot had an horizontal length of about 60 feet and was mined to a depth of 200 feet from the surface. The southwest end was 60 feet below the surface. The shoot averaged about 3½ feet wide and had a maximum width of about 7 feet. The minerals present were chiefly galena and ruby silver in a quartz gangue; cerussite, sphalerite, iron sulphide, and siderite also occurred. In the bottom of the ore-shoot iron sulphide and sphalerite were the predominant minerals.

At the time of the writer's visit the workings were inaccessible, but material on the mine dump, which had been obtained chiefly from the lower workings, was examined and found to contain pyrite, marcasite, sphalerite, galena, quartz, siderite, and minor amounts of pyrargyrite, chalcopyrite, chert, and manganese oxide. For further details of the deposit the reader is referred to the above-mentioned report by Cairnes.

The vein continues southwesterly from the Silver King property through two claims, the Mabel, owned by W. J. Tormey, and the Adam, owned by M. Evans. Material on the dumps of shafts sunk in the vein include siderite, ankerite, limonite, quartz, galena, and pyrite; both the siderite and ankerite are as a rule blackened with manganese oxide. No important ore-bodies have been found on these two claims, although a few tons of ore are said to have been shipped from the Adam claim.

Northwesterly from the Silver King claim the vein has apparently not been found. On the Webfoot claim, which is owned by J. Alverson and is the first claim to the northeast of the Silver King property, some manganese oxide and a small amount of pyrite were found on the dump of a prospect shaft; this shaft, however, lies northwest of the prolongation of the strike of the vein. The northeast extension of the vein has possibly been offset to the south by a cross-fault which occurs higher up on Galena creek; this conclusion is supported by the fact that ruby silver float is reported to have been found to the south of the strike of the vein in a ground-sluice on the Webfoot claim.

RICO CLAIM

This claim is situated on the eastern slope of Galena hill near Crystal lake. It is owned by H. A. Stewart.

The workings consist of a ditch, shaft, and tunnel. The shaft exposes a vein in a zone of brecciated quartzite. The vein probably strikes northeasterly. The minerals observed by the writer are limonite, manganese oxide, a little ankerite, and very minor amounts of quartz and pyrite.

BLUEBIRD CLAIM

This claim, owned by A. McLeod, H. Rhor, and S. Turpin, is situated low down on the northeast slope of the hill. A vein striking north 25 degrees east and dipping 62 degrees southeast was exposed during the spring of 1925 by means of two open-cuts. The vein is mineralized with galena, sphalerite, and pyrite in a gangue of ankerite, calcite, quartz, limonite, and manganese oxide. The country rock is greenstone and along the foot-wall it contains disseminated pyrite. The galena is reported by the owners to assay 292 ounces of silver to the ton and 77 per cent lead.

TIN CAN CLAIM

This claim, owned by A. McLeod, H. Rhor, and S. Turpin, is situated low down on the eastern slope of the northeast end of Galena hill. The workings consist of a ground-sluice, two shafts, and a few open-cuts. The shafts have exposed a vein which strikes about north 50 degrees east and dips steeply southeast. Judging from the material on the dumps, the vein is mineralized with ankerite, calcite, quartz, sphalerite, pyrite, and a small amount of siderite, limonite, and manganese oxide. A small amount of galena is reported to have been found also. The owners report that the two shafts, which were filled with water at the time of the writer's visit, are 32 and 15 feet deep, that in the deeper shaft the vein is well-defined and about 3 feet wide, and that the hanging-wall is greenstone and the foot-wall is schist.

EAGLE CLAIM

This claim, situated on the eastern slope of Galena hill at the head of McLeod creek, is owned by A. McLeod, S. Thurbur, and Miss J. Stewart.

A vein which strikes about north 50 degrees east and dips steeply southeast has been prospected by means of several open-cuts, prospect shafts, and ditches. On the northwest side of the vein the country rock is largely green and yellow mica schist and graphite schist; on the southeast side the country rock is quartzite. Judging from the material on the dumps the vein is mineralized with quartz, siderite, pyrite, galena, sphalerite, limonite, and malachite.

JUPITER CLAIM

This claim, owned by R. Fisher, is situated at an elevation of about 2,900 feet just west of Sandy creek on the northwest slope of Galena hill.

An open-cut in greenstone exposes a small vein which strikes north 53 degrees east and dips 80 degrees southeast. The minerals present in the vein form bands parallel to the walls of the vein and include quartz, ankerite, calcite, limonite, pyrite, arsenopyrite, sphalerite, and a little native gold and white mica. Small values in both gold and silver have been reported.

BETTY CLAIM

This claim is situated at an elevation of about 3,700 feet just east of Sandy creek on the northwest slope of the hill. It is owned by A. Wightman.

Two small open-cuts in greenstone have exposed a narrow vein which strikes about north 58 degrees east and dips to the southeast. The minerals present are quartz, calcite, galena, sphalerite, arsenopyrite, pyrrhotite, cerussite, and limonite. The owner states that near the top of one of the open-cuts the chief ore mineral was galena; at greater depth sphalerite was most abundant and in the bottom some pyrrhotite was found. These changes took place in a vertical distance of only 3 or 4 feet.

CRYSTAL KING CLAIM

This claim, situated on Crystal creek at the foot of the northern slope of Galena hill, is owned by F. Swanson, O. Dahl, A. E. Erickson, and M. Evans.

The workings, which are now caved, appear to be entirely in schist. The property was described in 1918 by W. E. Cockfield[1] who states that there are five arsenopyrite-gold quartz veins which, owing to the fact that they are thin and not very persistent, are not likely to prove of economic value. One of these veins or stringers strikes north 54 degrees west and is vertical; another strikes north 20 degrees west, and dips 50 degrees southwest. There is also a shear-zone 3 feet in thickness; it strikes north 74 degrees west and dips northeast at an angle of 60 degrees. Scattered irregularly through the rock of the shear-zone are small bunches of quartz, galena, arsenopyrite, pyrite, and sphalerite. Small values of silver and gold occur both in the veins and in the shear-zone. For further details the reader is referred to Cockfield's report.

[1]Geol. Surv., Canada, Sum. Rept., 1918, pt. B, pp. 9-10.

SILVER-LEAD DEPOSITS IN ATLIN DISTRICT, B.C.

By W. E. Cockfield

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INTRODUCTION

Towards the close of the field season of 1925 a week was devoted to a study of certain silver-lead deposits in Atlin district, B.C. Deposits of this type have been known for a number of years in this region, but of recent years they have been brought more into prominence by the increasing market value of lead. Some of the deposits had been previously reported upon by Cairnes,[1] but since that time little or no work such as would add to the available data has been done on them and, therefore, they were not again visited. The work was, therefore, restricted practically to the Atlin Silver Lead Mines (Ruffner group). A hurried trip was also made to a prospect in the vicinity of Surprise lake. The writer was ably assisted in the field by N. T. Ellis.

The chief silver-lead deposits occur on Leonard mountain in the vicinity of Fourth of July creek, where a large number of claims have been staked. The bulk of the more recent work, however, has been confined to one group; the claims of the Atlin Silver Lead Mines, Limited, more commonly known as the Ruffner group. These are situated on the mountain above timber-line, about 14 miles by road from Atlin. Adjoining the Ruffner group is the Big Canyon group, which received considerable attention at an earlier date, and which was reported on by Cairnes. A third group situated near Surprise lake in the valley of Pine creek about 12 miles from Atlin was also visited.

Atlin, the distributing centre for the district, is served throughout the summer months by the lake steamers of the White Pass and Yukon route; the steamers connecting with the railway at Carcross, a point situated 68 miles from tidewater. In winter a road is maintained across Tagish and Atlin lakes from Carcross to Atlin.

[1]Cairnes, D. D.: "Atlin Mining District"; Geol. Surv., Canada, Mem. 37, pp. 109-114 (1913).

GENERAL GEOLOGY

Leonard mountain is underlain by intrusives which consist of light to grey, coarse-textured rocks with a granitic habit. These rocks are in many places porphyritic with feldspar crystals exceeding an inch in length. Small bodies of an aplitic phase were also noted. These rocks in appearance and lithology are identical with the intrusives of the Coast Range batholith, which lies some distance to the south. The intrusive body around Leonard mountain is deemed to be an outlying mass of that batholith, probably contemporaneous or nearly so with it; and forms one of the numerous outlying bodies of granite in Atlin district. The granitic intrusive has been extensively invaded by dark green, dense, finely-textured dykes.

When observed under the microscope the granitic intrusives exhibit quartz and orthoclase with plagioclase, hornblende, and biotite, as well as a number of accessory constituents. Orthoclase is the most abundant mineral, with quartz and the ferromagnesian minerals next in importance. The plagioclase is oligoclase. The rock is, therefore, a granite in composition, rather than a granodiorite, which is the prevailing type of the Coast Range intrusives. The dyke rocks for the most part consist of hornblende and mica, with orthoclase and some plagioclase, and augite. Hornblende is the predominant mineral, and occurs in long prisms. The feldspars except in two instances do not occur as phenocrysts. The rocks are typically hornblende lamprophyres, and may be regarded as basic differentiation products of the granitic intrusives.

ORE DEPOSITS

The ore deposits occur in the dyke rocks. Instances have been noted where the ore minerals lie at the contact of the dyke rocks with the intrusives, and in one case within the intrusive itself a short distance from the contact; but on the whole the ore is confined to the dyke rocks. These have been shattered by faulting and the ore has been deposited in the fracture zones both in fissures and cavities, and as a replacement of dyke rock by sulphides.

The ore minerals are galena, zinc blende, and arsenopyrite, with some chalcopyrite and pyrite in a gangue of quartz, calcite, and ankerite. The deposits are prevailingly low in silver and gold values; certain exceptions to this will be noted in the description of occurrences.

A striking feature of the deposits is the persistency with which the fracture zones and mineralization are confined to the dykes. In one instance on the Big Canyon group a fault zone has been traced over 3,000 feet, and over this entire distance it is confined to a dyke not exceeding 15 feet in thickness. On the Ruffner group, although the intervals between workings are too large to permit of saying definitely that the veins have been traced for the entire distance, still the evidence points to the probability of the existence of veins upwards of 5,000 feet in length, confined to dykes not exceeding 30 feet in thickness.

This general condition would appear to be due to the fact that, prior to the injection of the lamprophyre dykes, a number of well-defined planes of weakness had developed and that these were followed by the main dykes at the time of their intrusion; and also, that subsequent to these intrusions relief from stresses which developed in the earth's crust has been found along the same lines of weakness. It is at least evident that faulting has been active along these planes, not only before the lamprophyre intrusions, but also subsequent to them, and indeed continuing after the deposition of the main bodies of mineral. Whether the localization of the faulting subsequent to the lamprophyre intrusions was due to the original planes of weakness or the more brittle character of the dykes as compared with the granitic intrusive, remains an open question. Faulting continued active even after the deposition of the main bodies of mineral, as more recent veinlets of quartz cutting the sulphides can be observed in the field and on a minute scale in thin sections under the microscope.

The dyke rocks from their composition may be assumed to be basic differentiates from the granitic magma, probably injected into the upper and cooler part from a still liquid lower part. Cairnes regards the deposits as genetically connected with the dykes. This is undoubtedly true, but the injection of the dykes themselves was in all probability merely a phase of the intrusion of the larger body of granite, and the writer prefers to regard the ore-bodies as being due to solutions from the lower liquid parts of a magma, the upper part of which had consolidated and into which had been injected dykes which had also been shattered, giving channels along which the vein solutions penetrated.

Mineralization occurred along fracture zones in the dykes. The fractures are not simple fissures; but rather zones in which the dyke rock has been more or less shattered. The ore minerals filled fissures and cavities in the dykes, and also replaced the brecciated dyke material itself. Of these processes, replacement was probably the most important. The mineralization is simple; galena, arsenopyrite, and zinc blende form the important ore minerals. With these are associated pyrite and chalcopyrite, and in one instance ruby silver (pyrargyrite) has been reported, but was not noted by the writer. The gangue minerals are quartz, calcite, and ankerite. The outcrops are prevailingly leached and oxidized so that values contained are small; but the depth of oxidation is always shallow, rarely exceeding a few feet.

DESCRIPTION OF PROPERTIES

ATLIN SILVER LEAD MINES, LIMITED

The Atlin Silver Lead Mines, Limited, has a group of sixteen claims and fractions locally known as the Ruffner group. This group is a trusteeship which is under the management of J. M. Ruffner, of Atlin, B.C., one of the trustees. The money for the development and equipment of the property is being advanced by the Federal Mining and Smelting Company, in consideration of a 55 per cent interest in the property. Under the terms of the agreement all sales of ore and concentrates are to be credited against the cost of operation until the mine has become a profitable producer; after that stage is reached the Federal Company receives 75 per cent of the profits until reimbursed for its outlay, after which time the Federal Company receives 55 per cent of the profits.[1] In addition, a number of claims outside the group, the property of J. M. Ruffner, have been leased to the Federal Company.

[1]Engineering and Mining Journal Press, vol. 120, No. 11, p. 423 (Sept. 12, 1925).

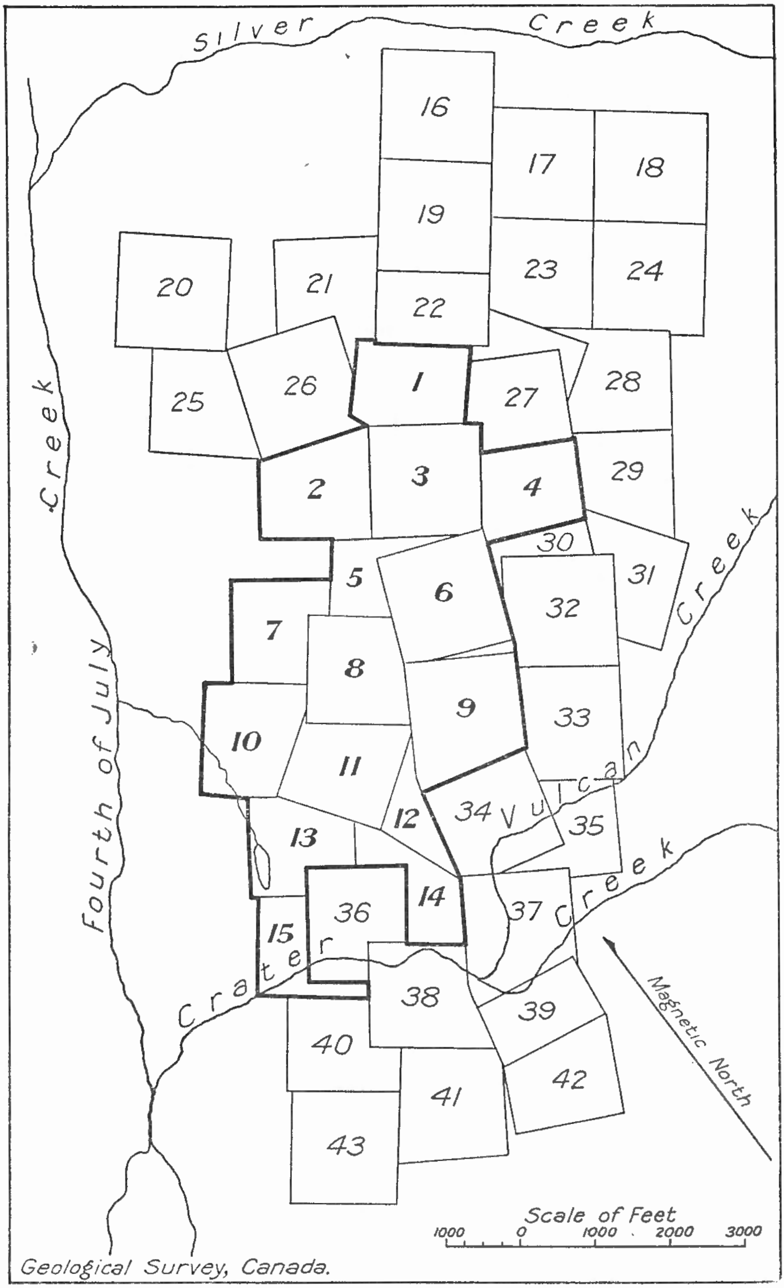

FIGURE 1. Atlin silver-lead mines (Ruffner group) and surrounding claims, Fourth of July creek, Atlin, B.C. The individual claim names are: 1, Cherokee; 2, Ptarmigan; 3, Tom; 4, Apache; 5, Silver Wedge; 6, Barber; 7, Mountain Hoboe; 8, Commanche; 9, Nellie; 10, Cranberry; 11, Portal; 12, Frontal; 13, Duck Pond; 14, Cabin; 15, Fourth of July; 16, Silver Creek; 17, Saddle Vein; 18, Black Hawk; 19, Grand View; 20, Silver Hill; 21, Musk Ox; 22, Jim; 23, Saddle; 24, Golden Eagle; 25, Silver Fox; 26, Horned Toad; 27, Twin Moose; 28, Silver Horn; 29, Bull Moose; 30, Arapano; 31, Iroquois; 32, Gambler; 33, Rambler; 34, Big Canyon No. 2 Extension; 35, Algonquin; 36, Blacksmith; 37, Big Canyon No. 2; 38, Big Canyon No. 3; 39, Big Canyon; 40, Lake Front; 41, Lookout; 42, Big Canyon Extension; 43, Choctaw.

The position of the claims of the Atlin Silver Lead Mines with respect to Fourth of July creek and to surrounding claims is shown in Figure 1. The claims stretch from near timber-line to the summit of Leonard mountain. The buildings necessary for present use have been constructed, a wagon road has been graded from the Fourth of July road to the workings, and the plant is equipped with the machinery necessary for prospecting, including several small compressors.

Deposits. Two main veins, No. 2 and No. 4, cross parts of the property. These with the workings on them are shown in Figure 2. Between the points shown as workings in the figure, the veins have been projected according to their dip and strike, and though, owing to the long, drift-

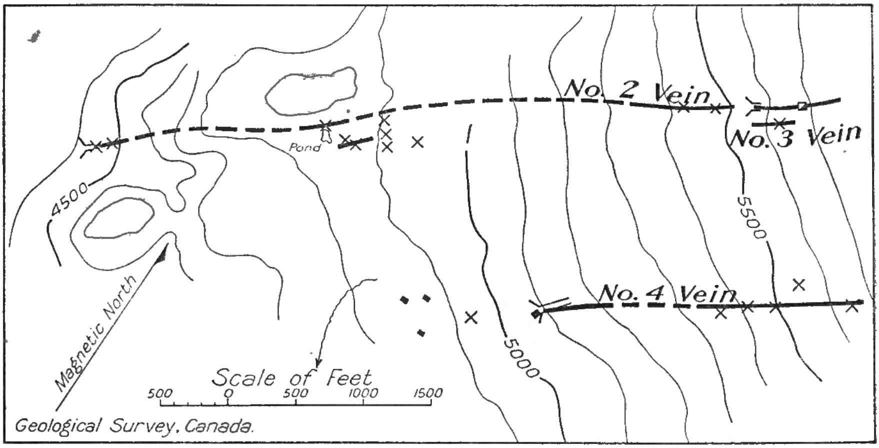

FIGURE 2. Part of Atlin silver-lead mines (Ruffner group), Fourth of July creek, Atlin, B.C. Outcrops of veins are represented by heavy lines, and the supposed continuation of the veins by lines of dashes. The positions of prospect pits and trenches are indicated by crosses.

covered intervals between open-cuts, it is impossible to state definitely that these open-cuts are all on two main veins, yet the facts point to such a conclusion. A third vein, No. 3, of small dimensions, has also been located at two points.

Workings. The workings consist of a shaft, three adits, and a number of open-cuts or trenches. The earlier workings lie well up the slope towards the peak between Vulcan and Fourth of July creeks. On vein No. 2 the upper or easternmost workings consist of a shaft 75 feet deep situated on the Cherokee claim, with a drift into the hill along the vein, 110 feet long at a depth of 50 feet. A short drift to the west was also run at the same depth. These workings were inaccessible at the time of the writer's visit, being filled with water.

Proceeding in a westerly direction along the strike of the vein the next workings, also on the Cherokee claim, consist of an open-cut and adit, about 500 feet from the shaft. The adit in reality drifts along the vein for 190 feet, but was caved 30 feet from the entrance, so that entry was impossible. The vein material at this point has a thickness of about 6 feet and consists of quartz with disseminated sulphides.

Four hundred feet farther along the strike of the vein is an open-cut in which the vein is exposed for a length of 25 feet. It has a strike of north 45 degrees east, magnetic, and a dip of 60 degrees northwest. The vein has a thickness of 6 feet throughout the length exposed, and consists of dyke rock heavily impregnated with quartz and sulphides. In another cut a few yards farther west the vein is exposed for 20 feet, has a strike of north 53 degrees east, and a dip varying from 70 degrees northwest to nearly vertical. The hanging-wall is not exposed, but the thickness as shown is about 5 feet. As in the cut above, the mineralization consists of quartz with galena, zinc blende, and arsenopyrite; the sulphides in this case, however, apparently occur in well-defined bands from 1 inch to 6 inches thick.

In a cut 400 feet to the west of these workings a length of about 40 feet of the vein is partly exposed, the hanging-wall not being visible. The vein where exposed is 6 feet thick, and consists of dyke rock and quartz containing streaks of yellow and brown oxides which probably represent leached and oxidized sulphides. For the next 2,000 feet along the strike of the vein there are no exposures. Several cuts have been excavated, but these did not encounter the vein. An exposure 2,000 feet west of the above-mentioned workings is on the Commanchee claim and consists of an open-cut about 15 feet long, which is badly sloughed, so that only a part of a reddish earthy outcrop can be seen. The approximate thickness of the vein at this point is 11 feet.

No further work has been done on the vein until a point 1,600 feet farther along the strike is reached. Here, on the steep hill-side of Fourth of July creek on the Portal claim, a dyke occurs which has been trenched by six open-cuts. Below the lowest cut an adit 45 feet in length has been run with a drift along the foot-wall of the dyke and another close to the hanging-wall 25 and 20 feet long, respectively. The strike of the dyke is north 45 degrees east magnetic, and the dip is 75 degrees northwest. As shown by the underground workings the dyke, partly concealed by timbering, has an approximate thickness of 25 feet. No sulphides were observed on the foot-wall side of the dyke, but the drift towards the hanging-wall side showed a heavy band of sulphides 6 inches wide, with disseminated sulphides through the dyke rock. The sulphides at this point are galena, zinc blende, and arsenopyrite, with some chalcopyrite and pyrite. In excavating the drift ruby silver (pyrargyrite) was reported, but none was observed in place.

In the six cuts above the adit, the upper two did not reach bedrock. Of the lower cuts the third is 50 feet long but is sloughed, so that the vein could not be seen. The fourth showed 20 feet of mineralized dyke rock, the fifth 20 feet of dyke rock with a shear-zone near the centre heavily stained with oxides, and the sixth 20 feet of dyke rock with mineral showings near the hanging- and foot-walls.

High assay values have been obtained at this showing. One assay shows \$60 in gold and 699 ounces of silver and another \$8 in gold and 447 ounces of silver to the ton. These assays were taken over a width of 2½ to 4 feet. The average of the assays at this point, properly weighted to the widths over which they were taken, is \$17.66 in gold and 265·34 ounces in silver. This average includes the higher assays.

Vein No. 3. No. 3 vein occurs 140 feet south of No. 2 vein and is exposed in two open-cuts, one near the shaft, and one 3,000 feet westerly along the strike. This occurrence is only of minor importance economically, and yet is important as showing the character and continuity of the deposits. This dyke has a thickness of about 3 feet and strikes north 45 degrees east magnetic and dips 85 degrees northwest. At its exposures in open-cuts it is shattered and mineralized. At the lower cut there is a heavy stain of yellow oxide on the outcrop, with a seam of 2 inches of sulphides close to the hanging-wall. At the upper cut the general characteristics remain the same, but the mineralization is much more scanty.

Vein No. 4. Vein No. 4 is situated 1,600 feet south of vein No. 2 and has been traced on the surface for a distance of over half a mile. At the lower end of the vein, on the Barber claim, is an adit 300 feet long, which follows the vein. One hundred and eighty feet from the entrance, a crosscut 20 feet long has been run towards the foot-wall side of the dyke.

As shown by the workings the dyke, at the point where it has been cut across, has an approximate thickness of 24 feet. At this point there is a band of sulphides 2 feet wide near the hanging-wall of the dyke, with more or less disseminated sulphides in the shattered dyke rock. Throughout the length of the adit bands of sulphides from 6 inches to 2 feet in width appear, with considerable earthy oxides. Near the face of the adit sulphides were observed in the granite several feet from the contact of the dyke with the granite. The strike of the dyke averages north 45 degrees east magnetic and the dip 63 degrees northwest.

In the upper cuts on this vein the dyke and vein material were found, but at the time of the writer's visit these cuts had sloughed so badly that little could be ascertained with regard to thickness and amount of mineralization. In the first cut above the adit there are apparently two bands of sulphides, one towards the hanging-wall and the other towards the foot-wall side of the dyke.

A large number of samples have been taken in independent examinations of the properties. These show a gold content usually less than $4 to the ton and averaging about $6 to the ton if high assays be included. At most of the cuts, however, the gold content runs from $2 to $4 to the ton. At the adit on the Portal claim the average of the samples taken is $24.80 in gold, weighted according to the widths over which the samples were taken. The silver values at the adit on No. 4 vein, Barber claim, run about 15 ounces over an average width of 3 feet 6 inches. On the higher cuts on this vein the values are lower, running 1·24 ounces over an average width of 2·9 feet. On the lower workings on No. 2 vein the higher assays show $60 in gold and 699 ounces in silver, with an average of $17.66 in gold and 265·34 ounces of silver to the ton. This average includes the higher assays. Lead is usually from 6 to 16 per cent of the ore.

A fairer estimate of the contents of the ore can perhaps be made by the result of two shipments, one of 30 tons made in July, 1924, from the shaft on No. 2 vein, and the other of 10½ tons from the adit on No. 2 vein, Portal claim.

The smelter returns from these shipments were furnished by Mr. J. M. Ruffner.

Shipments from Atlin Silver Lead Mines

—	No. 1	No. 2
	30 tons shaft No. 2 vein	10½ tons adit No. 2 vein
Gold	0·16 ozs. per ton	0·11 ozs. per ton
Silver	75·70 " "	193·95 " "
Lead	29·25 per cent	7·7 per cent
Zinc	12·40 "	3·10 "

As many of the open-cuts were sloughed in and in others only the oxidized material from the vein outcrop was available the writer made no attempt at a systematic sampling of the property. A few samples were taken from No. 4 vein at its best exposures to serve as checks on the values stated. Two of these, Nos. 1 and 2, were from the adit near the crosscut and No. 3 from the upper workings of the same vein. The results of these assays are given below.

Sample No.	Gold Ozs. per ton	Silver Ozs. per ton	Lead Per cent
1	0·10	7·24	0·56
2	0·03	8·35	2·70
3	0·11	7·58	5·69

BIG CANYON GROUP [1]

As little or no work has been done on the Big Canyon group since reported on by Cairnes in 1910, this group was not visited. The following description is summarized from Cairnes' report, and added for sake of completeness.

Big Canyon group consists of four claims adjoining the Ruffner group on the south. It was located in 1899 and is owned by Messrs. J. Malloy, Thomas Vaughan, and M. Summers. Two main veins occur on the property, the lower of which crosses Crater creek just below the forks of the stream, and the upper of which crosses the west branch of the creek a short distance above the forks. In addition several smaller veins have been found.

As on the Ruffner group, the veins are really mineralized basic dykes cutting granite. The lower dyke has a thickness of 8 to 15 feet and has been traced for 3,000 feet. The upper dyke is 30 feet thick and has been traced for several hundred feet. From one-third to one-half of the dykes consist of ore minerals—galena, arsenopyrite, zinc blende, quartz calcite, and ankerite. These materials occur filling fissures in the dykes and have also replaced brecciated dyke material.

Description of Veins. The upper vein dyke strikes north 40 degrees east magnetic and dips 80 degrees to 85 degrees northwest. It has an average thickness of 30 feet and can be traced on the surface for several hundred feet. This dyke where visible is roughly divisible into three bands of about equal thickness. The upper zone has been subjected to repeated faulting,

[1] Cairnes, D. D.: "Atlin Mining District"; Geol. Surv., Canada, Mem. 37, pp. 109-114 (1913).

and now consists of brecciated fragments, cemented together with quartz, the proportion of cement increasing as the central part of the dyke is reached. The middle zone contains the bulk of the ore minerals, partly in one or more fissure veins and numerous narrow veinlets, and also in irregular bunches which lie between or have replaced the brecciated fragments. The lower 10 feet of the dyke has been only slightly affected, but lying along the foot-wall is a vein of ore about 1 foot thick.

The lower vein strikes north 40 degrees east and dips 80 to 90 degrees northwest, and may be traced for a distance of 3,000 feet. This dyke much resembles the upper one; but is not characterized by distinct zones. The mineralization has a width of 4 to 12 feet. As in the upper dyke, the ore occurs in fissures and in irregular bodies replacing the original dyke rock.

Workings. On the upper vein two tunnels have been driven of unknown lengths, but probably exceeding 100 feet. On the lower vein a shaft 40 to 50 feet deep has been sunk. This, with several open-cuts and pits, forms the development work of the property.

SURPRISE GROUP

The Surprise group consists of two claims staked by W. G. Sweet, J. Tolmier, and P. L. Eggert. These claims are situated at timber-line on the south side of Pine Creek valley at the foot of Surprise lake, about 12 miles from Atlin. The claims represent part of a group previously staked which had been allowed to lapse.

The country rock consists of chlorite schist belonging to the Gold series, a series of altered, basic, igneous rocks, probably of late Palæozoic age. Cutting the chlorite schist is a quartz vein striking north 10 degrees west, magnetic, and dipping 70 degrees southwest. This vein varies from 3 feet to 20 feet in width, and carries minor amounts of galena, chalcopyrite, and calcite. The bulk of the deposit, however, is formed by quartz, apparently barren of sulphides.

The workings consist of an adit and an open-cut. The adit is 50 feet long with a winze of unknown depth 15 feet from the entrance. The winze was filled with ice and was inaccessible at the time of the writer's visit. The open-cut is situated about 100 feet above the adit.

At the entrance to the adit the vein is 6 feet wide, and narrows to 3 feet at the face. Practically no sulphides were observed in this distance. The winze apparently encountered a small shoot of sulphides, but owing to its being filled with ice no details could be obtained.

At the open-cut the vein has a width of 20 feet, but includes several narrow bands of country rock. The quartz has been brecciated and recemented with calcite, but as at the adit, galena and chalcopyrite occur only sparingly.

SUMMARY AND CONCLUSIONS

The veins of Leonard mountain are mineralized basic dykes cutting granite. The dykes are probably basic differentiates from the granitic magma and the ore deposits are probably due to solutions from the same source.

These dykes carry important amounts of mineral, but there has not yet been sufficient work done to tell whether the mineral occurs throughout the shear-zones in the dykes or whether it is confined to definite shoots of ore along the fracture zones in the dykes. There can be very little doubt as to the continuity of the dykes over considerable distances, and it seems probable that the shear-zones are also persistent. As the bulk of the ore will probably require concentration before shipment the most pressing work required at the present time is to determine if the tonnage available is sufficient to justify the erection of a mill. This work involves demonstrating the size of the ore-bodies, and learning if the ore is continuous throughout the shear-zones, or is concentrated in the form of ore-shoots.

Other similar dykes occur beyond the limits of the Ruffner and Big Canyon groups, and there is a probability that some, at least, of these are mineralized.

EXPLORATIONS BETWEEN ATLIN AND TELEGRAPH CREEK, B.C.

By W. E. Cockfield

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Illustration

Map 2097. Reconnaissance between Atlin and Telegraph Creek, B.C. (in two sheets).....In pocket

INTRODUCTION

The field season of 1925 was devoted to a reconnaissance of the country between Atlin and Telegraph Creek, northern British Columbia. This region was practically unknown from a geological standpoint, but, considering the known deposits of mineral in Atlin district on the one hand, and the reported discoveries of placer gold in the vicinity of Dease lake to the east, seemed worthy of examination. It was traversed by many thousands of gold seekers on their way to the Klondike discovery in 1898; and surveys for the Dawson-Ashcroft telegraph line also crossed the district, but on the whole the amount of knowledge of the topography and general geology of the district was small.

The area covered lies between latitudes 57° 50′ and 59° 40′ north and between longitudes 131° and 133° 40′ west. It may be reached either from Atlin or from Telegraph Creek. Atlin is connected with Skagway by rail and lake steamers operated by the White Pass and Yukon route. Telegraph Creek may be reached from Wrangell by means of the river boats of the Barrington Transportation Company which operate on Stikine river. Both Skagway and Wrangell are regular ports of call for the coastal steamers from Vancouver and Seattle.

From Atlin to Telegraph Creek a pack trail follows in part the Yukon telegraph line and affords a fair means of access to points situated between these two villages; with the exception of some poorly defined trails used by hunting parties it is the only trail in the district. In the vicinity of the telegraph line, travel to points off the main trail is not difficult, but farther west and south numerous canyons render travel by pack train extremely difficult, and this difficulty is enhanced by the lack of natural fodder for pack animals.

The method of mapping adopted was to run a rough traverse between Atlin and Telegraph Creek, which would serve as a control for the remainder of the survey. This was subsequently adjusted between the positions of Atlin and Telegraph Creek. From this main traverse, side traverses were run, which, combined with plane-table sketches from the summits of prominent hills, permitted the making of a rough map of much of the region. One of these side traverses was carried south to Inklin river and down it to Taku river, thus connecting with the maps of the International Boundary Commission. Geological work was carried on along all traverses, and as a result it was possible to determine the main features of the geology of a strip of country of varying width along the trail from Atlin to Telegraph Creek.

The writer was assisted by Messrs. N. T. Ellis, B. B. Brock, J. A. C. Harkness, and J. Marin, all of whom performed their duties in an able and satisfactory manner.

TOPOGRAPHY

The region traversed lies to the east of the Coast range, and is characterized in a general way by a broad, dissected plateau, above which rise isolated mountain groups. Well rounded or flat-topped hills, and wide, deep valleys are the characteristic forms. The plateau continues to the northwest where it is known as the Yukon plateau, but the southern part of the area is a vast lava plateau dissected to some extent, age of which relative to that of the plateau to the north is unknown; it may be considerably younger. Some difference of opinion has developed as to the age of Yukon plateau, but it may be stated that the uplift to its present position occurred during late Miocene, Pliocene, or early Pleistocene time.[1] Work by W. A. Johnston and F. A. Kerr in Dease Lake district shows that some of the lava flows are Tertiary or early Pleistocene, so that the formation of the lava plateau may be very recent geologically.

The drainage of the region studied is almost entirely towards Taku river, the only exceptions being a small fringe on the north draining into Yukon River basin, and a similar fringe on the south draining to Stikine river. The main tributaries of Taku river are Inklin and Nakina rivers, the former being produced by the confluence of Sheslay, Dudidontu, and Nahlin rivers. All these rivers are swift and turbulent with high gradients. Taku river at the junction of Nakina and Inklin rivers is 300 feet above sea-level, whereas Nakina river at the crossing of the telegraph trail, 35 miles above, measured along the valley, has an elevation of 2,000 feet above sea-level. The average grade is thus nearly 50 feet to the mile. Most of this drop in elevation, however, occurs in the 25 miles below the trail crossing, the grade for the last 10 miles being comparatively low. Similar figures were obtained for other parts of the main drainage. Many of the streams flow for long distances in sharply cut canyons, and practically all tributaries enter the main streams through canyons. This is particularly noticeable in the tributaries of Inklin river, on some of which drops of 300 feet to the mile were noted. These canyons where definite evidence could be obtained are post-Glacial cuttings, and are probably due to changes in level following the Glacial period, to changes in drainage or diversion of streams, and possibly to the overdeepening of the main valleys by the glaciers.

[1]Cairnes, D. D.: "Wheaton District"; Geol. Surv., Canada, Mem. 31, p. 83 (1912).

Sheslay, Inklin, Taku, and parts of Sloko rivers are glacial streams, reaching high-water stage about the middle of July and maintaining this stage until well on into September.

GENERAL GEOLOGY

The geology of the region, extending as it does southeastward from Atlin district, and consequently along the strike of the rock formations of that district, is in many ways similar to that of Atlin district. For some distance southeast of Atlin, the region is underlain by altered igneous and sedimentary rocks; farther southeast these probably occur, but are covered by large areas of basaltic rocks which extend to Stikine river. The ages of these rocks are not definitely known as no fossils were found, although careful examination was made of numerous outcrops. Such tentative correlations as are made rest, therefore, upon the lithological similarity between rocks of Taku basin and those of Atlin district as mapped by Gwillim.[1] The following table represents in a general way the relative ages of the rock formations found.

Table of Formations

Quaternary..........	....	Basalt, andesite, and associated tuffs
Tertiary............	....	Sandstone, shale, and tuff
		Quartz porphyry and granite porphyry
Mesozoic............	Cretaceous to Jurassic	Granitic intrusives
		Sandstone, shale, conglomerate, and tuff; chiefly pyroclastic
Palæozoic...........	Carboniferous to Devonian (?)	Greenstones; serpentine, magnesite, peridotite, etc.
		Crystalline limestone
		Cherty quartzite, slate, schist, and limestone

CARBONIFEROUS TO DEVONIAN (?)

Quartzite, Slate, Limestone. This group includes the oldest rocks recognized in the district. They are widespread in Atlin district and extend southeast towards Nahlin river. Their distribution is best seen by reference to the accompanying map (No. 2097).

The quartzites vary from black or grey to white, but are chiefly dark, fine-grained rocks, in which the bedding is only poorly preserved. Under the microscope they show approximately equal amounts of rounded grains of quartz and feldspar, the latter largely altered to calcite. Occasional shreds of biotite and flakes of graphite are present. The constituents are oriented along roughly parallel lines. The slates are black or grey and usually highly disturbed. Biotite is present in many cases and gives a glistening appearance to the exposed surfaces. Associated with the slates are minor amounts of chlorite schist. The limestone occurs in narrow bands closely associated with the slates and quartzites. Much altered volcanic material is interbedded with the rocks of this group. No fossils

[1]Gwillim, J. C.: "Report on the Atlin Mining District"; Geol. Surv., Canada, Ann. Rept., vol. XII, pt. B (1902).

were found in situ, but on a creek draining into Hatin lake a few fragments of poorly preserved fossils were observed as float. These were, however, too poorly preserved to admit of identification. The age of this group must consequently remain in doubt. It was classed by Gwillim as belonging to the Lower Cache Creek series of Carboniferous or possibly Devonian age.

Crystalline Limestone. This formation occurs over large areas, chiefly adjacent to Nakina river. The limestone is grey or slate-colour and practically all trace of the original bedding has been destroyed. No recognizable fossils were obtained, although a prolonged search over wide areas was made. Some of the limestone areas are continuous with those of Atlin map-area, which have been regarded as Carboniferous on the basis of fossil evidence reported by Dawson[1], who found *Fusulina* in some of these limestones. Later work has shown that possibly Triassic limestones may also be present, but until more definite evidence is available these limestones may perhaps be best regarded as Carboniferous.

Greenstones. The rocks classified under this heading occupy a large part of the region. Included with them in the mapping are numerous small bodies of quartzite and limestone which could not be separated either because of the scale of the map or for lack of time. It is probable that many diverse types are present, but all are derived from basic or semi-basic intrusives. They are highly altered and consist of serpentine, magnesite, or chlorite. Of the specimens chosen for microscopical examination, a number were entirely altered either to serpentine or to chlorite. In others residual masses of feldspar and olivine could be observed. It is likely that the predominant type has been derived from basic intrusives such as peridotite and pyroxenite.

In certain localities numerous small veins of asbestos were noted cutting the serpentines, but none with fibre exceeding one-eighth of an inch in length, nor were the veinlets sufficiently numerous to lead to the expectation of commercial deposits of that mineral.

These rocks were undoubtedly intruded into the limestones and quartzites mentioned above. Their age is in doubt, since the age of the sediments is also in doubt, but they may be tentatively classed as late Palæozoic or early Mesozoic.

CRETACEOUS TO JURASSIC

Sandstone, Slate, Conglomerate, etc. The rocks included under this head were found only on the lower part of Yeth creek and on Taku river, where they apparently constitute a belt following the trend of the eastern margin of the Coast Range batholith. Hayes,[2] who ascended Taku river, notes that this belt of rocks is approximately 8 miles wide. They were observed during the course of a somewhat hurried traverse of parts of Yeth creek, Inklin and Taku rivers, where on account of difficulties of travel, but little time could be devoted to their study. They consist principally of bedded tuffs, with occasional bands of sandstone, slate, and conglomerate. Coal is reported to occur in these rocks on a small stream that enters Yeth creek from the northwest about 4 miles above its mouth. No seams of coal were noted along the route traversed, although a canyon near the mouth of Yeth creek afforded continuous rock exposures for nearly 3 miles.

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[1] Dawson, G. M.: "Report On an Exploration in the Yukon District, N.W.T."; Geol. Surv., Canada, 1887, p. 170.
[2] Hayes, C. W.: Nat. Geog. Mag., vol. 4, pp. 117-159 (1892).

The bedding in the tuffs is best observed from a distance, as the individual beds are massive and very thick. The material of the tuffs is largely andesitic. The sandstones are dark, usually weathering to a brownish red, and contain more or less tuffaceous material. The slates are dark to black rocks with a pronounced secondary cleavage, and in the sections observed were highly disturbed. Locally, pebbles of limestone identical in appearance with the limestone described above are numerous, forming a slate conglomerate.

These rocks have been studied in much more detail in areas lying to the northwest, as in Atlin, Wheaton, Whitehorse, and Tantalus districts, where fossils found have been taken to indicate a Lower Cretaceous age for part of the group at least;[1] it may be stated, however, that a large part of the tuffaceous beds belong to the upper part of the Lower Jurassic and the lower part of the Middle Jurassic.[2] Until more detailed stratigraphic work is done in this region it is best to regard this group as possibly containing both Jurassic and Cretaceous members.

To the northwest it has been determined that wherever the upper part of the group, the Tantalus conglomerate, is fully developed, coal occurs. The Tantalus conglomerate is a formation readily recognizable in the field, as it is a hard, compact conglomerate composed almost entirely of pebbles of quartz, slate, and chert. This formation was not encountered by any of the traverses, but is known to occur in Atlin district.

Granitic Intrusives. Rocks grouped under this head include several diverse types, but all have a granitic habit. They are not, as a rule, true granites, but correspond more closely to the granodiorite family. These rocks southeast from Atlin district have only a very limited areal development. They occur on the telegraph trail towards the head of Dudidontu river and again near Egnell, and are present towards Inklin river along the traverse made in that direction. Lithologically they are very similar to the intrusives of the Coast Range batholith.

The rocks are grey to reddish, but the greyish varieties predominate. Typically they are coarse-grained rocks exhibiting quartz, feldspar, and hornblende or mica and have usually a granitic habit, though locally, porphyritic phases with feldspar crystals exceeding an inch in length are developed. The specimens examined under the microscope consisted of orthoclase and plagioclase feldspar, quartz, augite, hornblende, and biotite as essential constituents. The rocks fall essentially into two groups. The most common type consists of orthoclase and acid plagioclase (oligoclase), in nearly equal amounts, quartz, hornblende, and biotite with a number of accessory constituents, and fall into the group classed as granodiorites, or according to the usage of many petrologists, quartz monzonites. The other type consists of plagioclase and augite, with orthoclase, hornblende, biotite, and a number of accessory constituents, and may be classed as augite diorites.

No definite evidence of the age of these rocks was obtained in the area explored, owing to their extremely limited areal development. It was found that they are younger than the serpentine rocks and older than

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[1]Cairnes, D. D.: "Lewes and Nordenskiöld Rivers Coal Area"; Geol. Surv., Canada, Mem. 5, pp. 34-38 (1910). "Wheaton District"; Geol. Surv., Canada, Mem. 31, pp. 56-59 (1912). "Atlin District"; Geol. Surv., Canada, Mem. 37, pp. 62-64 (1913).

[2]Cockfield, W. E., and Bell, A. H.: "Geology of the Whitehorse District"; Geol. Surv., Canada, Mem. 150.

the basalts. The main body of the Coast Range batholith is at present assumed to be of late Jurassic age, and it is probable that these outlying bodies belong to the same general period of intrusion.

TERTIARY

Quartz Porphyry, Granite Porphyry. The only considerable body of these rocks found was on Heart mountain. A number of dykes also occur along Dudidontu river. They are in general white or yellow rocks, aphanitic to porphyritic in texture, the latter variety exhibiting crystals of quartz or feldspar. Under the microscope crystals of quartz and orthoclase can be seen in a micr족granitic groundmass. Where definite evidence as to their relative age could be obtained, it was ascertained that they were older than the basalts and younger than the serpentines. On account of their lithological similarity to rocks occurring to the northwest, where more definite evidence of their age has been obtained, they are provisionally referred to the Tertiary.

Sandstones, Shales, and Tuff. This group was found at one locality only, namely on the bluffs overlooking Nahlin river, opposite Nahlin telegraph station. It consists of slightly coherent sandstones and shales with some intercalated volcanic tuff. The sandstones are grey to brown, are only slightly indurated, and except that they are partly consolidated resemble deposits of modern river sands. The shales are grey to brown, thinly laminated, and only partly consolidated rocks. The exposures occur along the northern bank of Nahlin river, where a section, approximately 100 feet in thickness, is exposed. Neither the top nor bottom of the section could be seen. The rocks are bent into a series of easy folds, which are somewhat disturbed by faulting. Owing to their occurrence at a single locality, separated by wide areas covered by drift, from the other rocks of the region, no determination as to their age could be reached nor were any fossils obtained from these rocks. On account of their loosely coherent condition, and the relatively slight disturbance which they have undergone, as contrasted with some of the other formations of the region, it is believed that they are relatively young and they are provisionally assigned to the Tertiary.

TERTIARY AND QUATERNARY

Basalts, Andesites. This group includes the youngest, and one of the most widesperad, of the rock formations in the region. From the head of Koshin river southwards to Tahltan river the trail skirts the base of Level mountain for nearly 50 miles; along Tahltan river it skirts the southern edge of that mountain, which appears to be almost entirely underlain by nearly horizontal flows of lava. The lavas also occur west of the trail and appear to cross Sheslay river. The southern part of the region, therefore, may be considered as a huge lava plateau into which the streams have cut to varying depths.

The lavas are grey to black, dense, finely-textured to porphyritic rocks, presenting typical flow structures. They include both andesites and basalts. The andesites are in general porphyritic rocks with phenocrysts of feldspar of varying size in a greyish or greenish groundmass.

Under the microscope both hornblende and augite andesites were seen to be represented. The basalts are black rocks with basic plagioclase (labradorite) with or without olivine and in many cases contain a considerable percentage of brownish glass. In some cases the prismatic jointing peculiar to this type of rock was extremely well developed. Although there was not sufficient time available to study these flows in detail it was noted at several points that the andesites formed the older, and the basalts the younger, flows. It is not known if this relation holds true for the whole region. It is also impossible to state definitely the number of flows involved. Dawson[1] was able to demonstrate that on Stikine river there were at least four flows of basalt.

The basalts and andesites are younger than all the rocks they were observed in contact with, that is the granitic intrusives, porphyries, and greenstones. More definite evidence as to their age was obtained by W. A. Johnston and F. A. Kerr of the Geological Survey, working in Dease Lake district, who place them in the Tertiary with some of the most recent flows of Stikine valley probably belonging to the Pleistocene. The amount of erosion since the formation of the upper flows in the district studied is very great, for canyons 1,500 feet or more deep have been cut through these rocks.

ECONOMIC GEOLOGY

The investigation of the region from the standpoint of mineral resources proved disappointing. In the first place extremely large areas are covered by flows of recent volcanics, in which signs of mineralization are almost totally lacking. In the remaining part of the region, the lack of large intrusive bodies, particularly of the more acid type allied to the intrusives of the Coast range, leads to the belief that the region is not as favourable ground for prospecting as other regions where such intrusives do occur. That this should be the unavoidable conclusion is all the more disappointing because to the northwest, in Atlin district, along the strike of the same rocks, large bodies of granitic intrusives form a feature of the geology, and placer gold and lode deposits of gold, silver, lead, and copper are known. It was hoped that similar conditions would prevail to the southeast. It must be remembered, however, that a large area, still unexplored, lies between Sheslay and Inklin rivers and the Coast range. This region is extremely difficult of access, and prospecting it will be slow. Large areas are covered by snow fields, the topography is rugged in the extreme, and apparently there are few streams adapted to navigation. The area which can be covered in a single season will, therefore, be limited, but this region will probably furnish much better territory for prospecting than the district adjacent to the telegraph trail. Mineral deposits have been reported on Taku river, near the International Boundary, but these lie a considerable distance beyond the area mapped in the summer of 1925.

Coal has been reported from Sloko lake in Atlin district and also from Yeth creek. No opportunity was afforded of visiting either locality during the past summer, but the presence of coal-bearing formations was noted. Where these coal-bearing rocks have been studied to the north it has been found that there are two horizons with coal seams, one near the top of the Tantalus conglomerate, and another in the Laberge beds,

[1]Dawson, G. M.: "Report On an Exploration of the Yukon District"; Geol. Surv., Canada, 1887, pp. 68-69.

some distance below the Tantalus conglomerate.[1] It is not known if these horizons persist throughout the coal basins of northern British Columbia and southern Yukon, but wherever the Tantalus conglomerate has been found and is at all extensively developed, coal does occur. This formation is easily recognized as it is composed almost entirely of pebbles rarely over 2 or 3 inches in diameter of chert, quartz, and slate, whereas all other conglomerates of the region contain pebbles of various rocks such as limestone, granite, volcanic rock, and so forth. The Tantalus conglomerate wherever found should be searched for coal.

The work of a number of investigators in the districts to the northwest of Taku basin has made apparent that the majority of ore deposits in such districts are intimately associated in origin with the Coast Range batholith and with intrusives of similar character which have been regarded as outlying parts of that batholith. It seems apparent that search for mineral in Taku basin must be carried south farther than reached by the present survey. The difficulties of prospecting this region will be great, on account of the many obstacles to travel.

[1]Cairnes, D. D.: Lewes and Nordenskiöld Rivers Coal Area"; Geol. Surv., Canada, Mem. 5, pp. 35-48 (1910).

GOLD PLACERS OF DEASE LAKE AREA, CASSIAR DISTRICT, B.C.

By W. A. Johnston

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INTRODUCTION

Interest in the old placer mining field of Cassiar in northern British Columbia was revived by the discovery, in August, 1924, of placer gold on Goldpan creek, a tributary of Little Eagle river. In the spring of 1925 about two hundred prospectors and miners entered the region. Machinery (including a drag-line scraper outfit, over 30 tons of hydraulic pipe, and a Keystone drill) was taken into the district for use on Dease, Thibert, and McDame creeks, on which most of the mining was done in the early days. These creeks have long been regarded as mined out in so far as mining could be carried on by hand methods. Their possible adaptability for profitable hydraulicking has been recognized for several years and to render the district more accessible and to lower the excessive transportation costs, the British Columbia government has recently constructed a wagon road, to replace the old pack trail from Telegraph Creek to Dease lake. The past season's(1925) work on Goldpan creek resulted in a gold production of only about $7,500, but the work was done by hand methods as in the early days. The results showed that the region still has possibilities for placer mining even by hand methods. Such methods, however, are not very profitable and the chief interest in the region at the present time lies in the possibilities for hydraulic mining on a fairly large scale and for gold dredging.

The field work upon which the present report is based was done during the season of 1925 and included an examination of Goldpan creek and other tributaries of Little Eagle river, Eagle river, and the well-known Dease and Thibert creeks. McDame creek, the only other gold-bearing stream of known importance in the region, was not examined. It is a large stream flowing into Dease river from the west about 55 miles below Dease lake and time was not available for its examination.

The present writer was ably assisted in the field work by G. W. H. Norman and M. S. Hedley. Acknowledgments are also due to officials of the Hudson's Bay Company, and the Barrington Transportation service, to W. Scott Simpson, Indian agent at Telegraph Creek, and to many prospectors and mining men in Dease Lake district who freely supplied information.

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LOCATION AND MEANS OF ACCESS

The summer route to Dease Lake area in Cassiar district is by way of Wrangell, Alaska, and Stikine river to Telegraph Creek. Wrangell, near the mouth of the Stikine, is reached in two and a half days by steamship from Vancouver. Well-equipped river boats maintained by the Barrington Transportation Company make weekly trips from Wrangell to Telegraph Creek, a distance of 146 miles, stopping en route at the Customs House at the Boundary. The trip upstream is made in two to three days depending on the stage of the water; downstream, usually in one day. Boat service on the river is maintained from about the middle of May until October, but can be extended somewhat beyond these dates.

Dease lake, which is the central point for distribution of supplies in Cassiar mining district, lies just north of the Arctic divide in northern British Columbia. The lake is connected with Telegraph Creek by a road 73½ miles long, only recently constructed. During the past summer the Hudson's Bay Company operated a caterpillar tractor hauling two trailers of 5 tons capacity, which made regular weekly trips over the road. Caterpillar tractors were also used by two of the mining companies for transportation of mining machinery and supplies into Dease lake. Motor trucks were also used over parts of the road and two trucks actually reached Dease lake in the early part of the season, but were put out of commission shortly afterwards by the bad condition of parts of the road. By the end of the season sufficient work had been done on the road to permit of motor traffic except for a few miles near the Dease Lake end. It is expected that by the latter part of the summer of 1926 the road will be in condition for motor traffic and that motor trucks will be able to make the trip from Telegraph Creek to Dease lake in one day.

On Dease lake the Hudson's Bay Company has scows fitted with small gasoline engines, that travel back and forth from the post at Porter landing near the north end of the lake. Posts are also maintained by the company at McDame creek and farther down river near the junction of Dease and Liard rivers. Transportation between the lower posts and the one on Dease lake is by scows manned with Indians. During the summer of 1925 the Hudson's Bay Company maintained a store at the head of Dease lake, and a store was established by a private individual at the mouth of Goldpan creek. Two motor boats were brought into the lake, one being operated by F. Reid and used during the summer for transportation of supplies and passengers on Dease lake and river. The other was used by a party of prospectors from Victoria, B.C., for a prospecting trip down Dease river and up the Liard. These boats remain on the lake and will probably be operated next season. The mining companies operating on Dease creek maintain scows for transportation of machinery and supplies from the head of Dease lake to the mouth of Dease creek.

Roads and pack trails extend to various parts of the district. The old pack trail along the west side of Dease lake and down Dease river to McDame creek is easily passable from the head of the lake to Dease creek, but is with difficulty passable between Dease creek and Thibert creek and is in disuse below Thibert creek. Practically all the transportation is by water. A good pack trail extends up Dease creek for about 8 miles and a road was under construction in 1925. A road extends from Porter landing for 6 miles to the old hydraulic mine on Thibert creek and in 1925 was in a good state of repair except the bridge at Deloire creek and near the Thibert Creek end where slides have occurred. Pack trails extend up Thibert creek from the end of the road to Mosquito creek and to French mountains. A pack trail extends from the head of the lake for about 19 miles to Goldpan creek. It leaves the main wagon road about 2 miles from the head of the lake. The trail to Turnagain or Little Muddy river leaves the trail about 4 miles south of Goldpan creek and extends up Squaw creek and through a low pass in Cassiar mountains. The present writer's party had no serious difficulty in travelling with pack horses down Eagle river nearly to its mouth and across country to the foot of Dease lake. There is an abundance of feed for horses from the latter part of May until October or November, and travelling with pack horses is feasible throughout the greater part of the district. Many of the prospectors use dogs as pack animals. As game is abundant, prospecting trips extending over several weeks may be made in this way. In winter dogs are used almost entirely for travelling.

The usual winter route into Cassiar is by way of Atlin; by steamship to Skagway, thence over White Pass and Yukon railway to Carcross, by stage over the ice on Tagish and Atlin lakes to Atlin, and thence by trail to Telegraph Creek and Dease lake. The trail from Atlin to Telegraph Creek is a pack trail for the most part. Ten trips a winter are made over it for mail service. In summer the trail is passable for pack horses. An alternative winter route is up Stikine river from Wrangell. A number of prospectors went in to Telegraph Creek with dog teams by the Stikine route in March, 1925. In most winters, however, the very heavy snowfall in the Coast Mountain section of the river and open water in places on the river, render travel by this route difficult.

Telegraph Creek has several stores and an hotel, as well as a Hudson's Bay Company's post. It is the main outfitting point for prospectors going into Cassiar and for big game hunters. During the season of 1925 twenty-eight big game hunters and a number of tourists came into the area. The hunting parties use pack horses, of which 150 to 200 are usually available in the district, and travel 50 to 150 miles from Telegraph Creek. The district is famous for its big game which includes mountain sheep, goat, cariboo, moose, and bears. The hunting parties and tourists are an important source of revenue to the inhabitants of the district. The scenic beauty of the Stikine River route and the Great canyon of the Stikine above Telegraph Creek, which has been rendered accessible by the construction of the motor road from Telegraph Creek, have long been recognized. It is expected by the Barrington Transportation Company, who have placed a new and fairly large motor passenger boat on the river, that there will be a marked increase in tourist traffic. The district is also of considerable importance for the production of furs, nearly all the district and a large part of the little known region lying to the north and northeast being pretty well covered by trapping lines. Many of the trappers spend the summers in prospecting and in placer mining. It is stated that during the past few years the general scarcity of fur-bearing animals in the district has rendered trapping not very profitable.

PREVIOUS WORK

Practically all that was known, previous to the work by F. A. Kerr and the present writer in 1925, regarding the geology of the region, is contained in a "Report on an Exploration in the Yukon District, N.W.T., and adjacent Northern Portion of British Columbia", by George M. Dawson and R. G. McConnell, publication No. 629, Geological Survey, Canada. The report was originally printed in the Annual Report of the Geological Survey, volume III, part I. It was reprinted as a separate in 1898 at the time of the Klondike rush and the maps accompanying it were revised and brought up to date. Copies of the report (without the maps) are still available for distribution. Dawson and McConnell's work was done in 1887 and was a reconnaissance survey of the geology along the regular route of travel via Stikine river, Dease lake, and Dease river to the Liard. Dawson proceeded up the Liard to the Yukon and McConnell downstream to the Mackenzie. In the report considerable information is given regarding the old placer workings in Cassiar.

The Annual Reports of the Minister of Mines, B.C., contain most of the information available regarding placer-mining operations in Cassiar. A very good description of the route into Cassiar by way of the Stikine and of mining conditions in Dease Lake area is given by Wm. Fleet Robertson in the Annual Report of the Minister of Mines, B.C., for 1912. A more recent description with special reference to hydraulicking possibilities of Dease creek is given by H. G. Nichols, Canadian Mining Journal, March 28, 1924.

CLIMATE

The annual precipitation is heavy along the Stikine in the Coast Range section extending for about 75 miles from the coast. During the winter snow accumulates to a considerable depth on the flats along the river and remains until the latter part of May or June. The remarkably heavy snowfall explains why glaciers in places extend down nearly to the river-level, although the mean annual temperature is comparatively high. Telegraph Creek, however, and a stretch along the river for about 35 miles above and below the town, is in the "dry belt". The precipitation is very light and irrigation is necessary in most seasons for the growing of farm crops which, however, is done at only a few places in the benches along the river. In Dease Lake area, because of the greater altitude, the summers are cooler and the precipitation somewhat greater than at Telegraph Creek. No records of precipitation in the area are available, but judging by observations during 1925 and the statements of residents the average precipitation does not exceed 30 inches and is probably between 25 and 30 inches. It varies greatly from year to year. The summer of 1925 was exceptionally wet, some rain falling in parts of the area on eighteen days in July and on twenty days in August, but only on four days in September. The total precipitation, however, was small. During the warm part of the summer, which lasted about two weeks, thunder showers occurred nearly every day, but there were few heavy rains during any part of the season.

The average snowfall in the vicinity of Dease lake is said to be only 3 to 4 feet. In the higher mountainous parts of the area north and east of Dease lake, the snowfall is considerably greater and the snow remains there in some years until the latter part of June or July. There are, however, no permanent snowfields or glaciers of appreciable size even in the highest parts of Cassiar mountains. In 1925 the snow had almost entirely disappeared from the mountains by the latter part of June and, although light snowfalls occurred on the summits occasionally during the summer, no snow remained on the summits until October.

Summer temperatures in the area are reported to be fairly high in some years, but only rarely to exceed 80 to 85 degrees F. The nights are nearly always cool and many light summer frosts occur. Potatoes, however, have been successfully grown for many years at Porter Landing on Dease lake. The ice leaves Dease lake usually during the first week in June and closes the lake early in December. The earliest date on which the lake was clear of ice, according to the records of the Hudson's Bay Company, was on May 22, 1924, and the latest on June 16, 1887. High water in the streams tributary to Dease lake and Dease river usually occurs in June. In 1925 it occurred a few days after June 5, when the ice disappeared from Dease lake. In some years freshets, due to rapid melting of the snow in the mountains or to heavy rains, occur in July and occasionally also in August. Low water occurs in the autumn and winter. There is also in most years a short period of low water in the spring after the ice breaks up in the streams. In the early days of mining in the district, when "wing damming" of the beds of the creeks was the standard practice, serious losses were sustained, because it was not known that freshets occurred fairly late in the summer. The Gold Commissioner reported in 1875 that the dams washed out by the freshet on Dease creek represented a loss of nearly $50,000[1].

Winter temperatures of –40 to –60 degrees F. are reported to occur occasionally in the area. Although the winters are cold the ground is not permanently frozen except locally. There are numerous springs which flow the year round and are sufficiently large in places, as on Mosquito creek, to prevent the creeks, for a short distance at least, from freezing in winter.

The average length of the hydraulic season in the area, as shown by the results of hydraulicking on Thibert creek, is about four months, from June 1 to October. Hydraulicking was carried on for fifteen years and showed that the amount of water available from the watershed varied greatly from year to year. Unfortunately no records of precipitation, nor records of discharge of the creeks, are available, so that it is impossible to determine, except very approximately from the flow of the creeks in one season, how much water can be made available over a period of years, for hydraulicking in any part of the area.

Statements by a prospector named Perry and by others, regarding the occurrence of a tropical or semi-tropical valley in northern British Columbia, have appeared in newspapers from time to time during the past few years and have attracted considerable attention. Information about the so-called "tropical or semi-tropical" valley was obtained by the present writer from prospectors in Dease Lake area who have wintered at the locality. The basis for the reports apparently is that hot springs occur in Liard River valley near the mouth of Smith river (site of old Fort Halkett) and at intervals along the Liard down to Devils portage or the head of Grand canyon. The springs keep the ground in their immediate vicinity warm and moist, so that crops planted in the neighbourhood of the springs have a longer growing season than would ordinarily be the case and, therefore, are surer than at other places in the region. But there is said to be very little arable land, as the valley is comparatively narrow, is bordered on the south by the northern extension of the main range of the Rockies, and on the north by other mountains. It is stated that small plots of wheat have been sown and that the wheat grows luxuriantly, but does not mature because of the early frosts. A Mr. Smith, who was drowned last spring in attempting to run the rapids of Grand canyon, of the Liard, is said to have lived with his daughter (who came through the rapids of the canyon alive) for several years at the locality and to have raised good crops of potatoes and other vegetables. The springs can have no appreciable effect on the climate because climatic conditions are mainly controlled by atmospheric conditions. The locality is far north and far inland, so that climatic conditions are necessarily fairly severe. The springs have long been known to Hudson's Bay Company employees of the region and were seen over twenty-five years ago by Charles Camsell, Deputy Minister of the Department of Mines, Ottawa. They are probably somewhat similar to the Banff hot springs, but have not been investigated, so that little is definitely known regarding their character and origin.

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[1]Ann. Rept., Minister of Mines, B.C., 1875, p. 4.

HISTORY OF MINING AND PROSPECTING

Accounts of the discovery of placer gold in Cassiar are given in the Annual Report of the Minister of Mines, B.C., for 1876, in Bancroft's History of British Columbia, and by G. M. Dawson in his "Report on an Exploration in the Yukon District, N.W.T., and Adjacent Northern Portion of British Columbia." The accounts differ somewhat in detail, but all agree that McCulloch, a Scotch traveller, was the discoverer of gold on the Liard, and Henry Thibert, a French Canadian, the discoverer of gold in Dease Lake area. Dawson states in his report (page 82): "Henry Thibert, a French Canadian, left the Red River country in 1869 on a hunting and prospecting expedition to the west. In 1871 he met McCulloch, a Scotchman, and together they passed the winter near the abandoned site of Fort Halkett, on Liard river, suffering no ordinary hardships from scarcity of food. Near this place, probably on what was known afterwards as McCullochs bar, gold was first found. In 1872 they reached Dease lake, having been informed that it was a good locality for fish, with the intention of securing a sufficient supply for the ensuing winter. Being told, however, by the Indians, that white men were engaged in mining on the Stikine not far off, they crossed by the trail from the head of the lake and reached the mining camp of Bucks bar. Early in 1873 they set out on their return to the original discovery of gold, but meeting with success on Thibert creek, at the lower end of the lake, they were deterred from going farther and remained working there during the summer, being joined afterwards by thirteen other miners from the Stikine. Dease creek was discovered during the same season, and Capt. W. Moore was among the first to begin work there. Thibert is still mining in Cassiar, but McCulloch lost his life some years since on a winter journey on the Stikine."

According to accounts that have been handed down by "old timers" in the area, McCulloch did not return to Dease lake with Thibert in 1873, but at the start of the return journey fell through the ice on the Stikine and, though rescued, died from exposure shortly afterwards. Thibert was then chosen as leader of the party in place of McCulloch and the party proceeded to Dease lake where boats were built with which to return to McCullochs bar. Other prospectors, however, who had followed the party, stole the boats, and Thibert's party turned their attention to prospecting locally. Gold was discovered on a low bench on the north side of what was afterwards known as Thibert creek, about 3 miles above the mouth, and not far from the mouth of Deloire creek. The discovery was made by one of Thibert's men, but Thibert was granted the Discovery claim as leader of the party. McCullochs bar proved of little value, but Thibert and Dease creeks produced considerable amounts of gold for several years.

Regarding the history of mining in Cassiar subsequent to the original discoveries and up to 1887 Dawson[1] states: "In 1874 the population, exclusive of Indians, was estimated to have reached 1,500. The placers of McDame creek were discovered. Miners descended the Liard a long distance, and worked McCullochs bar and other river bars. Prospectors ascended the same river and reported having been within sight of Frances lake. The little town of Laketon was built at the mouth of Dease creek,

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[1]Dawson, G. M.: "Report On an Exploration in the Yukon District, N.W.T., and Adjacent Northern Portion of British Columbia"; Geol. Surv., Canada, vol. III, pt. B (1889).

and beef cattle were for the first time brought across country from the Upper Fraser. The total yield of gold from the district (which, from a mining point of view, includes the Stikine) is roughly estimated to have been equal to $1,000,000.

"In 1875 the population is estimated to have been 1,081, and the yield of gold equalled about $830,000. Three hundred head of cattle were brought from the Fraser overland. This and the preceding season were the best years of the district. Of a small party which spent the winter of 1874-75 far up the Liard river, four died of scurvy. Prospecting was actively carried on in outlying regions, Sayyea creek being discovered near the Liard headwaters, and the Frances river also apparently examined.

"Owing to the flattering accounts sent out, a great influx of miners occurred in 1876, the population at one time being estimated at 2,000. Profitable work, however, could not be found for so many men and the yield of gold fell to $499,830. Walker creek, said to be 70 to 80 miles east of McDame creek, was discovered, but this stream never proved very remunerative. Defot creek was also found and in 1878 proved rich for a limited area.

"Since this time the production of the district and the number of miners employed have gradually declined, and no important new creeks have been discovered, though reports to that effect have from time to time been circulated. The Black or Turnagain (Little Muddy) river is the most recent of these, some attention being drawn to it in 1886. It appears, indeed, that after the first few years very little prospecting or exploring has been done at a distance from the main creeks, of which Dease, Thibert, and McDame have been the most important and permanently productive."

At the time of the Klondike rush in 1897 and 1898 considerable attention was directed to Cassiar district because two of the overland routes, one by way of Telegraph Creek and Dease lake and river, and the other by way of Finlay, passed through the district. The Finlay route from Edmonton, Alberta, extended up Finlay and Fox rivers to Sifton pass and down the Kechika (Muddy) river and across by way of Deadwood lake to Sylvester landing at the mouth of McDame creek. The latter route was traversed in 1898 by Inspector J. D. Moodie of the Northwest Mounted Police and described by him.[1] Several hundred prospectors passed through Cassiar by these routes and a number wintered in the district. At this time, also, the Yukon and the Cassiar Central railways were projected from Glenora on the Stikine 12 miles below Telegraph Creek, but were not constructed, although some grading was actually done for the latter railway. The Cassiar Central railway employed men for several seasons in prospecting for lode and placer deposits in various parts of the district. This work resulted in the undertaking of hydraulic mining on a fairly large scale on Thibert creek. Hydraulicking continued from 1901 to 1922, except for six years when operations were suspended. In 1913 and 1914 drilling was done on the lower parts of Dease, Thibert, and McDame creeks to determine the value of the ground for gold dredging. Further drilling was done afterwards at the mouth of Dease creek and on Mosquito creek. During the past few years the possibilities of hydraulicking on Dease creek and at other places have been investigated. Two drag-

[1] "Edmonton to the Yukon"; Sessional Papers of the Parliament of Canada, 1899, No. 15.

line scraper outfits, one on McDame creek and one at the mouth of Dease creek, have been installed, the latter having been completed in the autumn of 1925. Two hydraulic plants are being installed on Dease creek and one on Mosquito creek. Hydraulicking is also proposed on Deloire creek and on Thibert creek below the old hydraulic workings.

The total gold production from Cassiar district amounts to about $5,000,000, of which nearly four-fifths was produced in the seventies and one-fifth since that time. Although placer mining has been carried on to some extent almost continuously since the discovery, the gold production has gradually declined and in 1923 and 1924 was practically nothing. Dease, Thibert, and McDame creeks have produced the bulk of the gold and strangely enough the large streams, Canyon, Cottonwood, Eagle, and Rapid rivers, have produced practically no gold, except on a few of their branches, although they apparently lie within the "gold belt" and have been pretty thoroughly prospected.

The part of the Cassiar that has been most carefully prospected for placer gold is that in the vicinity of Dease lake and Dease river. On the Liard a few paying bars were found, but except at a few places near the headwaters all the gold was very fine. Sayyea creek, a branch of the Upper Liard, about 180 miles above the mouth of Dease river, was prospected in the seventies and produced some coarse gold. Mining continued for two or three seasons and the creek was then abandoned. Hyland river, a large stream flowing into the Liard from the north, 12 miles below the mouth of the Dease, was ascended for about 140 miles by prospectors, but no paying deposits were found on it. Turnagain (Little Muddy) river east of Dease lake was ascended to its headwaters and was prospected at numerous places, but only fine or "bar" gold is said to have been found on it. The Kechika (Muddy) river was followed by the overland trail of 1898 to the Klondike, from its source down nearly to its junction with the Turnagain, and probably was fairly well prospected at that time if not during the early days. Walker creek, a branch of the Turnagain or Kechika, was mined for several seasons and was reached by a pack trail extending from Sylvester landing at the mouth of McDame creek, eastward up Sheep creek and over the divide. A trading post was established on the creek and was later taken over by the Hudson's Bay Company, but has been abandoned for many years. Only fine gold is said to have been found on the creek and only a few of the bars have paid to work. In 1874 prospectors found streams about 70 miles southeast of Dease lake, which are probably tributaries of Turnagain river, and yielded $6 a day in coarse gold. Considerable prospecting was also done in the region west and northwest of Dease lake; the headwaters of Tuya river and other streams flowing northwest were examined, but nothing of value was found.

For several years during the seventies there were from 500 to 1,000 miners and prospectors in Cassiar region. Many of these came from Cariboo and Omineca where they had had considerable experience in placer mining and in prospecting, so that it is probable much very thorough prospecting was done. Nevertheless, most of the prospecting seems to have been done by a very few of the more energetic prospectors, the rest being content to await the news of a "strike". Dawson stated in his report of 1887:

"Taking into consideration the great extent of generally auriferous country included in the Cassiar district, it must be conceded that, apart from the immediate vicinity of the well-known productive camps, it has been very imperfectly prospected. A great part of the district has, in fact, merely been run over in search of rich diggings, the simplest and cheapest methods of prospecting only having been employed in the quest. It is not improbable that additional rich creeks, like those in the vicinity of Dease lake, may yet be discovered elsewhere and it may be considered certain that there are great areas of poorer deposits which will pay to work with improved methods and will eventually be realized."

Since 1887 considerable prospecting has been done in the region with no very important results, but the region is so vast that it is very improbable that all the creeks have been prospected even on the surface and it is certain that many of the creeks have never been "bottomed" except where the ground is very shallow.

The prospectors who entered the region in the spring of 1925 confined their attention largely to Goldpan creek and its tributaries. A number left the district soon after coming, being convinced that the discovery on Goldpan creek was of no great value. About thirty remained on the creek during the summer. Only a very small amount of prospecting was done on the creeks adjacent to Goldpan creek, and no evidence of recent prospecting was seen in a traverse during the summer down Little Eagle and Eagle rivers. Grady, one of the discoverers of gold on Goldpan creek and one of the most energetic prospectors in the district, prior to starting work in July on Goldpan creek, spent several weeks in prospecting in the region east of the creek, but without success. Three or four parties using pack horses and dogs for travelling spent a few weeks during the summer in prospecting in the Turnagain River country. One party composed of John Palmer of Wrangell, and Ralph Hall, returned in July and reported having found nothing of value. Mr. Palmer had formerly prospected in Turnagain area and returned last year to reinvestigate a creek that he had previously examined. Another party composed of Frank J. Carter, a newspaper correspondent of Seattle, John L. Hosfeld, and Ralph Hall (who had accompanied Palmer) returned late in the autumn and reported having found gold on a creek which they named Palmer creek. The creek is a branch of Turnagain river or possibly of Kechika river and is said to lie about 60 miles northeast of Goldpan creek. About $2 in fairly coarse gold is reported to have been obtained by panning the surface gravels along the banks of the stream, and a number of leases were staked. A party of prospectors, composed of Messrs. Hawthornwaite, Gray, Hamilton, and others, from Victoria, B.C., brought in a motor boat to Dease lake and went down Dease river and up the Liard nearly to the Yukon boundary. They returned in September and reported having staked some ground on McDame creek. Two prospectors, "Bill" Perkins and "Red" Latimer, built a boat at the head of Dease lake and went down Dease river intending to prospect in the Liard country during the summer and if necessary to winter somewhere in the region. Four prospectors, two of them being from Cariboo, where they had had considerable experience in prospecting, did some work on Thibert and Porcupine creeks. They found sufficient prospects to induce them to remain in the country, and intend trapping during the winter. A little gold was found on Vowel creek, a tributary of Thibert in the upper part, by Phil Hankin who has been in the district for many years, and by "Captain" Scotti of Seattle. The ground was partly frozen and no definite pay-streak appears to have been found. Nearly all of the prospectors left for the "outside" in the autumn, but a number intend to return in the spring to work their claims on Goldpan creek and to carry on further prospecting.

Considerable prospecting was also done on the first north fork of Clearwater river which flows into the Stikine from the north about 30 miles below Telegraph Creek. The Clearwater is a large stream, but is not navigable because of the swift water and numerous canyons. The junction of the first north fork is about 12 miles above the Stikine. Prospectors state that a canyon begins on the North fork about 4 miles above the mouth and extends nearly to the headwaters. Placer mining was carried on for several years on bars on the stream a short distance below the canyon and several thousand dollars in gold was recovered. During the past summer discoveries of placer gold were made by Charles Spann on low benches a few feet above the river in the canyon. Two discovery claims about 6 miles apart were staked, one being near the mouth of Limpoke creek about 12 miles up the first North fork and the other higher up. Spann is reported to have obtained $128 in fairly coarse gold by a few days sluicing of the bench gravels. The gravels are reported to overlie boulder clay, the bedrock not being exposed. There is an old trail from the mouth of the Clearwater to the foot of the canyon on the North fork, but it is said to be a very difficult one because of the canyons along the Clearwater and its branches. About a dozen prospectors left the Stikine River boat on its second last trip down stream on October 1, and went in to the discoveries on the North fork by way of a trapper's trail up Shakes creek and over a fairly high divide to the canyon of the North fork. This route is said to be preferable to the one up the Clearwater, although the distance, about 35 miles from the mouth of Shakes creek, is somewhat greater. Previous to this rush only a few claims, besides the discovery claims, had been staked. Although the season was far advanced the prospectors—who had come mostly from Goldpan creek—hoped to be able to determine the value of the ground and make their way out to Wrangell before the "freeze-up". No information as to the result of their work is available.

The feasibility of prospecting the remote parts of Cassiar by using an aeroplane for rapid transit from one part of the district to another was demonstrated during the past summer. The plane, a Vickers-Viking amphibious flying boat, with Col. J. Scott Williams and C. T. Caldwell as pilots and carrying Archibald Little of Detroit, who was in charge of the expedition, was flown from Prince Rupert to Wrangell; thence up the Stikine valley to Telegraph Creek, a landing being made on the river about 6 miles below the town, and thence to Dease lake. About two months were spent in prospecting in the region and flying trips were made from Liard post at the mouth of Dease river to Frances lake and to other parts of the region. George Platzer and sons and William Perry who had had some experience in prospecting in Cassiar, accompanied the expedition. As an illustration of the time which may be saved by such a means of transport it may be mentioned that a return trip from the head of Dease lake to Liard post was made in one day, a trip, which, by the ordinary means of travel, would require from two to three weeks. It is doubtful, however, because of the great expense involved, whether such a method of prospecting is justified, unless time is a very vital factor. The same amount of prospecting could, probably, have been done in two seasons by the ordinary means of travel, at much less cost. No mineral discoveries of importance appear to have been made by the expedition.

TOPOGRAPHY

The greater part of the area surrounding Dease lake is mountainous and has considerable relief. Cassiar mountains form a belt about 50 miles wide north and east of the lake. They extend northwest and southeast in the form of a fairly definite mountain range that is reported by prospectors to extend southeast to the headwaters of the Finlay and for a long distance northwest. The mountains are rugged, are deeply dissected by stream valleys and glacial cirques, and have many sharp peaks 6,000 feet to at least 6,700 feet above the sea. The highest peaks in Dease Lake area are in the eastern part near the headwaters of Eagle river. The lowest part of the area is in the valley of Dease river in Cassiar mountains where the river has an elevation of about 2,200 feet. The maximum relief of the area, therefore, is about 4,500 feet. In the vicinity of Dease lake and between it and Eagle River valley on the east, there are large areas of low relief, at elevations of 3,500 to 4,000 feet, which have a general slope towards the southwest away from Cassiar mountains and appear to be continuations of the ancient valley of the Stikine. The present valleys of the streams, except the upper part of Eagle River valley, are cut several hundred feet below this upland level and in places isolated mountain peaks and ridges rise considerably above it. The upland surface is probably the equivalent of the plateau of the Fraser River country farther south in British Columbia—the Interior Plateau of Dawson—but is much less extensively developed. The small extent of the plateau country in Dease Lake region and also along the Stikine, where much the same conditions exist as in Dease Lake area, may be due to Cassiar mountains having formed a continental divide for long periods of time and the ancient streams flowing to the Pacific not being sufficiently extensive to effect very much erosion. They reduced only small parts of the region to base-level, whereas in Fraser River region large areas were base-levelled because the streams were much more extensive. Dease Lake region, therefore, is mostly mountainous, but contains areas of plateau country.

A striking feature of the area is the great valley of Dease lake. It lies on the southwest side of Cassiar mountains, but drains north by Dease river flowing through the mountains into the Liard, although it is separated from the valley of the Tanzilla, draining into the Stikine, by a broad pass only 100 feet above the lake. The pass at the head of the lake is drift-filled and is terraced in places, so that, post-glacially, when the lake stood 100 feet or more higher than it does now—possibly because the valley in the mountain part was still blocked by glaciers—and preglacially, the drainage probably was towards the south or the opposite to what it now is. Dease lake, as shown by soundings made by F. A. Kerr, has a maximum depth of nearly 400 feet. Marked features of the lake are the nearly straight rocky sides, the great depth in places close to the shore, and the hanging character of the tributary valleys. The valley of Dease river in the mountain section below Dease lake is broad and drift-filled. Bedrock does not outcrop in the valley bottom and the tributary streams, unlike those in Dease Lake section, are graded to a somewhat lower level than the valley flat of Dease river. The drift-filled valley at the head of the lake may have been the old stream outlet of Dease Lake basin at one time, and the drift-filled channel of Dease river, the outlet at another time. They may be sufficiently deep to partly explain the great depth of the lake basin. It seems more probable, however, as pointed out in a later part of this report, that the lake basin is due mainly to glacial ice erosion.

The fact that Dease river flows north through Cassiar mountains, although it heads on the southwest side, may be explained by assuming that the ancient river persisted in its course in spite of uplift of the mountainous area. It seems more probable, however, because of the comparatively short course of the stream on the southwest side of the mountains and because of the low pass at the head of the stream valley, that reversal of drainage took place as the result of stream capture by headward erosion of streams in pre-Glacial time, or as the result of glacial erosion and deposition. Two ancient streams, one flowing north and the other south or southwest, probably headed close together in Cassiar mountain; the stream flowing north proved more powerful and finally captured the headwaters of the other stream. Glacial erosion and deposition, however, have modified the topography to such an extent that it is not clear just what changes in the drainage occurred in pre-Glacial time.

Eagle River valley (*See* Map 2104 accompanying report by F. A. Kerr, this Summary) on the east is somewhat similar to Dease valley in that it extends north directly through part of Cassiar mountains to join Dease valley, but is unlike it in other respects. The tributary, Little Eagle river, occupies a valley that is a continuation of the main valley through the mountains and is parallel to Dease Lake valley. Unlike Dease valley it is evenly graded throughout, and though broad and drift-filled has no deep basin like that of Dease lake. It heads in a low divide near a branch of the Tanzilla flowing to the Stikine and throughout its course is several hundred feet above the level of Dease lake. The main stream heads in the mountains, flows southwest for several miles in a very broad, flat-bottomed valley, and joins Little Eagle valley to flow north through the mountains. This broad valley, in which the drainage is towards the southwest, appears to be part of the old drainage system of the Stikine. The valley has been considerably modified by glacial erosion and deposition and the present stream has cut a narrow, deep canyon in the bottom of the valley 2 to 3 miles above the junction. The general level of the valley is slightly above that of the upland surfaces of low relief to the southwest that are continuous with the ancient terrace-like slopes bordering the sides of Tanzilla and Stikine valleys. It seems probable, therefore, that the ancient drainage of the Upper Eagle River country was towards the southwest down the Stikine. The drainage was diverted to the north in pre-Glacial time, probably, by a stream that cut back through the mountains and captured the headwaters of the ancient stream flowing southwest.

Dease and Thibert, the principal gold-producing creeks in the area, are quite different in character from all the other creeks, in that parts of the old channels of the creeks, at considerable heights above the present streams, are preserved. This explains why the production of placer gold has been mainly from these creeks. They are specially described and their geological history given in this report under description of the creeks.

Numerous small lakes, most of which are shallow and are due to irregular deposition of the glacial drift or occupy small rock basins eroded by the ice, occur throughout the area. One lake known as Fish lake. draining into Little Eagle river, 7 miles below the mouth of Goldpan creek, is well supplied with fish, although there is a falls in the outlet stream which prevents fish from ascending.

Timber-line is at about 4,600 feet. Much of the area is fairly well timbered, chiefly with white spruce which grows to a good size and is the main mine timber. There are large areas, for example in the upper part of Little Eagle valley and in the vicinity of Goldpan creek, which are not timbered, although they are well below timber-line. The lack of forest growth is probably due to the prevalence of fires in exceptionally dry seasons, as is shown by the presence of charred stumps and irregularities in the surface of the ground apparently due to the partial burning of the moss and surface soil.

GENERAL GEOLOGY

PLEISTOCENE AND RECENT

The unconsolidated deposits overlying the bedrock consist of Recent (post-Glacial) alluvium, glacial drift formed during the Ice Age immediately preceding the present period, interglacial deposits formed during one or more periods of temporary retreat of the ice during the Pleistocene or Glacial period, and gold-bearing gravels, parts of which are pre-Glacial (late Tertiary) in age.

The Recent deposits consist of sands, gravels, silt, and muck or peat deposited in the beds and deltas and on the flood-plains and terraces of the present streams. They have been formed mainly by streams eroding the glacial drift and to a slight extent, in the stream channels, the bedrock. The deposits as a rule are only a few feet deep, but probably have considerable depth in the deltas of Dease and Thibert creeks.

Glacial drift is abundant in the area, and in places fills the valley bottoms to considerable depths. In many places it mantles the sides of the valleys and it has filled the old channels of Dease and Thibert creeks to a maximum depth of at least 200 feet. It occurs abundantly in places on the mountain slopes up to elevations of about 5,500 feet and is present in small amounts nearly up to the highest summits. Erratics occur on the mountains near the head of Goldpan creek at elevations of 6,000 to 6,500 feet. The general direction of movement of the ice-sheet, as shown by glacial striæ and the direction of transport of the drift, was south to a few degrees west of south. In Tanzilla and Stikine valleys, southwest of the area, the ice moved down the valleys. These valleys probably formed, for at least a time during the Pleistocene, a main avenue for drainage or outflow of the ice-sheet in the interior region. But as the Coast range offered a barrier to the free passage of the inland ice-sheet to the coast, it may be that the general movement, during the maximum stages of glaciation, was south across the upper part of Stikine valley; Stikine valley through the Coast range was not sufficiently large to provide adequate drainage for the inland ice. A remarkable feature is that the ice-sheet moved across the southwestern part of Cassiar mountains, for erratics derived from the north or northeast occur on some of the summits well within the mountains along Eagle River valley and glacial striæ trending south occur in places in the mountains up to elevations of nearly 6,000 feet. The striæ, as well as the distribution of the erratics, indicate that a main gathering ground of the ice-sheet lay in the northeastern part of Cassiar mountains or farther to the north or northeast.

Evidence of erosion by the main ice-sheet is not very marked, although the ice must have accomplished some erosion, for it moved across the region and transported the glacial drift that covers much of the upland surface. There are several volcanic cinder cones in Eagle River country that are over 1,000 feet high. They have steep slopes, are composed mostly of friable materials, and are easily eroded. Occasional erratics occur on their sides and summits, so that it is evident they were covered by the ice-sheet, yet they were not greatly eroded by the ice. They are elongated in the direction in which the ice moved; their cone-shape was partly destroyed by ice erosion. The main ice-sheet was hemmed in by the Coast range, and was forced to move south, but was nearly stagnant, except along the main avenues of drainage in the broad, deep valleys. It, therefore, accomplished comparatively little erosion except possibly in these valleys.

Evidence of erosion by valley glaciers, on the other hand, is very marked. Cassiar mountains in many places have been deeply dissected by cirque erosion and many of the valleys have the characteristic rounded outline or U-shape of glacially eroded valleys. The development of cirques in the mountains was most pronounced at elevations of 3,500 to 4,500 feet, much below the level reached by the main ice-sheet. The mountain glaciers coalesced on the lower ground and in the broad valleys to form a fairly continuous ice-sheet. Moraines formed by the glacier that occupied Dease Lake basin occur in the valley at the head of the lake and moraines formed by valley glaciers occur at other places.

The fact that the evidence of valley glaciation is much more extensive than that of erosion and deposition by the main ice-sheet, seems to show that the period or periods of maximum glaciation by an ice-sheet were comparatively short lived. Valley glaciers, however, are much more effective agents of erosion than is an ice-sheet hemmed in by mountain ranges, as was the case in this general region. It may be, therefore, that the main ice-sheet persisted for a long time. The glacial drift at the highest levels is only slightly weathered and it, as well as the drift at the surface in the valleys, evidently belongs to the same general period of glaciation—the latest. It is evident, however, that there was a long period during which only the parts of the area below about 4,500 to 5,000 feet were covered by the ice, for comparatively little erosion could have taken place in the mountain valleys during the maximum stage of glaciation, when practically the whole region was buried beneath the ice. The moraines in the valley bottoms show that the valley glaciers persisted after the main ice-sheet had melted away and were sufficiently active to cause erosion and deposition. It is probable that valley glaciation occurred at other times during the Pleistocene, prior to the development of the main ice-sheet or ice-sheets, but there is no evidence to prove that this was the case.

The thickness of the ice-sheet over Dease Lake valley, during the maximum stage of glaciation, was at least 4,500 feet. The upper limit of the ice is not definitely known, but it does not appear to have extended much above 6,500 feet, for some of the highest peaks of Cassiar mountains above this elevation, judging by their jagged form, appear to have projected above the ice. The average thickness of the ice, except in places over the deep valleys, may have been only about 3,000 feet.

The glacial drift consists in part of boulder clay, morainic materials, and boulders (erratics), the direct deposit of the ice-sheet and valley glaciers; in part of stratified silt and clay deposited in standing water; and in part of stratified sands and gravels deposited partly on land and partly in water by streams flowing from the ice. Along the sides of the stream valleys in the region, as on Dease and Thibert creeks, boulder clay occurs in many places at the surface and overlies stratified sands and gravels which are either glacial outwash deposits or are interglacial stream deposits. The sands and gravels in places are over 100 feet thick and contain only a few boulders. In places they are underlain by boulder clay. In other places they rest on bedrock or directly overlie the old gravels in the bottom of the ancient channels. They contain many foreign stones, are not weathered, and, therefore, are glacial deposits or were formed by stream erosion of glacial drift. That they are, probably, in part interglacial stream deposits, formed during a time of temporary retreat of the ice, is shown by their relation to the rock benches along Dease and Thibert creeks. Both creeks have series of rock benches marking old channels of the streams when they flowed at higher levels. The rock benches or old channels are buried beneath glacial drift and have been partly exposed by hydraulicking; even the lowest bench, a few feet above the present channel, is overlain by glacial drift. All the benches, therefore, are older than the present channel and the highest is the oldest. For considerable stretches the highest old channel is intact alongside the new channel and diversion of the stream into the new channel was evidently due to deposition of glacial drift in the old channel. The lower benches, therefore, were cut by the stream after the deposition of glacial drift in the highest old channel and before the deposition of the glacial drift on the lowest benches, that is during a time or times of temporary retreat of the glaciers. Most of the gravels were probably formed by streams issuing from the ice, but a part may have been deposited by ordinary streams in interglacial time.

PLACER DEPOSITS

The placer gold deposits occur in three or possibly four different ways. (1) In gravels resting on bedrock in the old high-level channels of Dease and Thibert creeks. These gravels are only a few feet thick and are cemented in places. They are probably pre-Glacial (late Tertiary) in age. They formed the most important source of placer gold in the district, except the beds of those streams in places where the old channel has been cut away. (2) In glacial or (and) interglacial gravels that partly fill the old stream channels and present valleys. Some gold was included in the glacial drift by ice-erosion of pre-existing placers and was reconcentrated to some extent by stream action. As a rule, however, the gold is scattered through these gravels and is only slightly concentrated into pay-streaks. (3) In post-glacial or surface gravels in the beds and on the low benches of the present streams. These gravels were rich in places where an old gold-bearing channel of the stream had been cut away by the present stream.

A fourth class includes the lava-buried placers. Gravels overlain by lavas and tuffs occur in Eagle River country, but are not definitely known to be gold-bearing. They occur in places along Stikine River valley.

The placer deposits and geological history of the important creeks of the area are more particularly described in the following section on description of the creeks.

DESCRIPTION OF THE CREEKS

GOLDPAN CREEK

Goldpan creek was so named by William Grady and J. H. Ford, the discoverers of placer gold on the creek, because two rusty gold pans were found in a tree at the mouth of the creek. Some prospecting on the creek is said to have been done in the early days by James Porter, a former gold commissioner in the district, and by others, and there is evidence of prospecting in the form of old test pits. The recent discovery was made in August, 1924, when $2\frac{1}{2}$ ounces of gold was recovered in two days sluicing. Following the announcement of the discovery in September practically the whole creek and its branches were staked by local prospectors and by parties from Wrangell, Alaska, who made a special trip on the river boat from Wrangell to Telegraph Creek. Some staking was also done, especially on the adjacent creeks, Castle and Squaw, during the winter, but no mining or development work was done on any of the creeks until spring. In March, 1925, a number of prospectors and mining men reached the district by dog team from Wrangell by way of Stikine river and the Telegraph Creek-Dease Lake trail. A few also came in by the trail from Atlin to Telegraph Creek. Considerable prospecting was done on the creek in April and May. Several prospect pits were sunk to bedrock, and on the right bank of Goldpan creek 1,000 feet below the junction of Dome creek, a deep cut to bedrock was made by diverting the water of Dome creek. The prospectors, numbering about one hundred, who arrived on the first river boats in the latter part of May and first week of June, were met on the trail and at Telegraph Creek by returning prospectors who condemned the creek as of no value. Among the newcomers were three women, one of whom, a Miss Warburton from Vancouver, proposed to work a claim on shares. She reached the halfway point between Telegraph Creek and Dease lake, but there turned back because of the discouraging reports. As the claims had been "laid over" by the Gold Commissioner until July 6, no work was done on the discovery claim nor on some of the other claims until that date. When work began on these claims it was found that at least in places gold did occur in paying quantities and this caused a renewed interest in many of the claims on the creek and its tributaries. Most of the claims, however, were abandoned during the early part of the season, but mining and prospecting on several claims was carried on throughout the season. The prospectors would possibly have been entitled to stake 80-acre leases, as the creek had been prospected before, but the Gold Commissioner wisely decided that it would be in the best interests to permit of staking only the ordinary sized claims. The discovery claim is 1,000 feet long and the others 250 feet. The claims are numbered consecutively above and below discovery. There are three claims below discovery down to the flat of Little Eagle river and over forty were staked above. The claims on the tributary creeks are numbered upstream from the junction with the main stream.

Goldpan creek and its tributaries rise on the southwestern slope of Dome mountain, a conspicuous peak of Cassiar mountains clearly visible from the head of Dease lake. A branch of the Tanzilla and branches of Eagle river also head near the sources of Goldpan creek. The lower part of the creek for nearly 1,000 feet up from the junction with the flat of Little Eagle river is a comparatively narrow, V-shaped rock canyon. At the junction the stream has formed an alluvial fan, the highest part of which is 22 feet above Little Eagle river. The creek valley widens somewhat above the canyon and has in places fairly flat stretches averaging about 150 feet in width, but the gradient is steep throughout and averages nearly 6 per cent from the mouth to the junction of Grady creek. Dome creek, near its junction with Goldpan, has a steep fall over bedrock for a short distance, but bedrock does not outcrop in the bed of the creek for nearly 1 mile above. A buried channel of Dome creek enters Goldpan valley about 500 feet below the junction of the creeks, at a point where a number of strong springs issue. The channel is filled with partly cemented glacial gravels. Goldpan creek, for a short stretch just above the junction of Grady creek, flows in a narrow rock canyon. A buried channel filled with glacial drift occurs on the south side of the canyon. Its presence is indicated, as in the case of the Dome Creek channel, by springs that issue from the foot of the bank at the lower end of the channel.

The character of the short tributaries on the south side of Goldpan is somewhat remarkable. Each has a small lake near the junction with the main creek and a nearly vertical rock cliff along the west bank and in places along the east bank. The lakes are dammed by deposits of glacial drift and Recent alluvium in the main valley and are drained by seepage through the drift filling.

The ground in the main valley varies from 3 to 5 feet in depth in the lower, canyon-like part, to 15 or 20 feet in the part above up to the mouth of Grady creek. In the flatter, wider stretch from Grady creek to the mouth of Jimmie creek the ground in places, as shown by shafts and test pits, is 25 feet or possibly more in depth. Higher up on the creek there are numerous rock outcrops and the ground for the most part is shallow. The ground on Dome creek for about 1 mile up from the mouth is probably at least 50 feet deep, but no shafts have been put down to bedrock, so that the exact depth is not known. The lower part of Grady creek is a narrow rock valley, the bottom of which was reached in a few places by prospect pits, a few feet deep, and by ground-sluicing. The upper part is drift-filled, but apparently only to a small depth.

The deposits overlying the bedrock in Goldpan Creek valley consist of glacial drift and to a lesser extent of Recent alluvium. The glacial drift

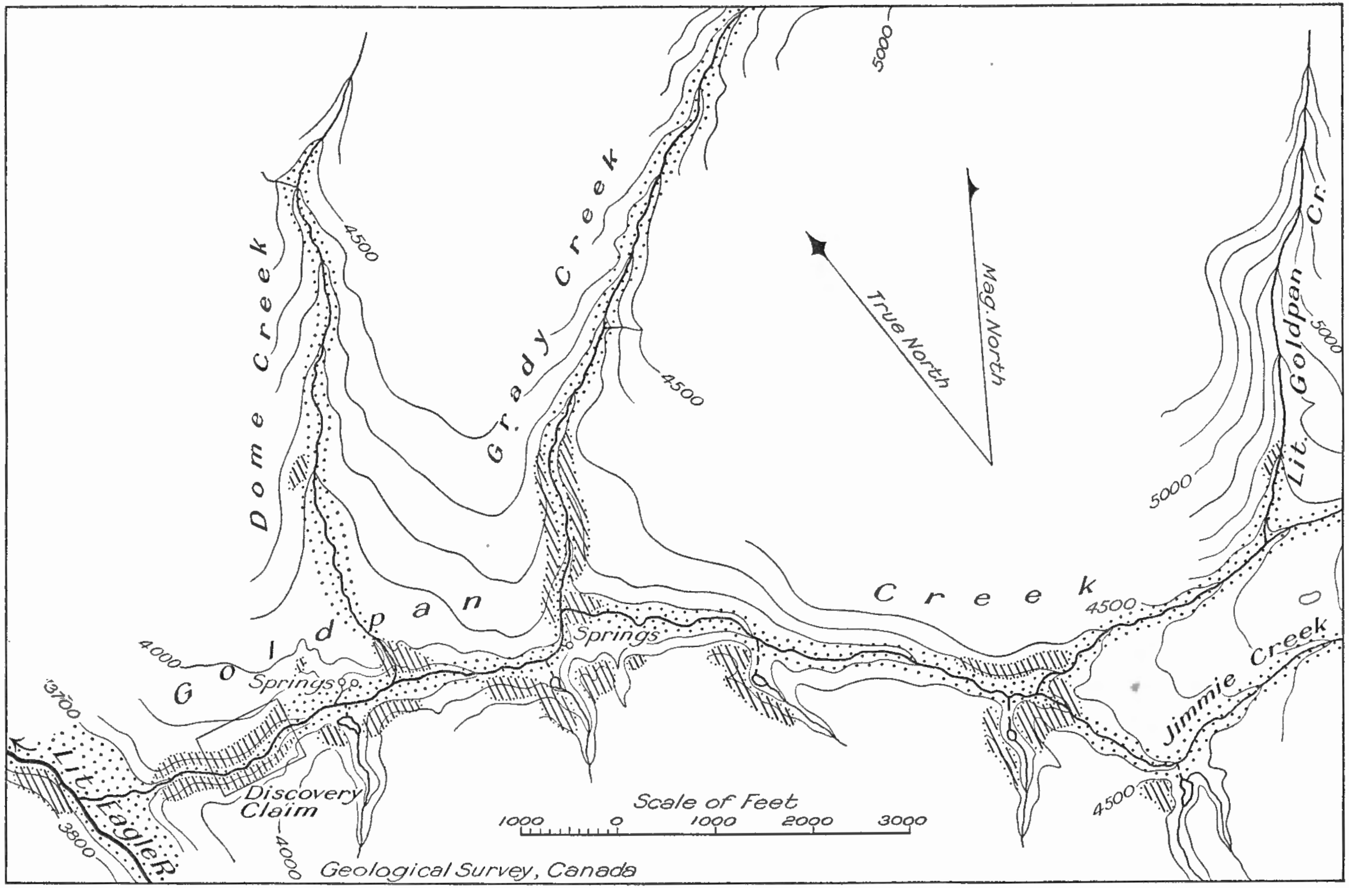

FIGURE 3. Goldpan creek, Cassiar district, B.C. Areas where bedrock outcrops are shown by a pattern of parallel lines; areas of Recent alluvium by a pattern of dots; areas without a pattern are occupied by glacial drift.

consists of boulder clay and sands and gravels. Since the disappearance of the glaciers from the region there has been very little rock cutting by the streams except in the canyons. The Recent alluvium has been formed chiefly by erosion of the glacial drift. The buried rock channels were formed before the last advance of the glaciers, for they are filled with glacial drift, but they do not appear to be preglacial (Tertiary) as they are steep-sided and have a youthful appearance. They were probably formed during the Pleistocene, partly by stream erosion, during times of retreat of the glaciers, and partly by ice erosion. The steep rock cliffs along the sides of the tributaries on the south side of Goldpan creek appear to be due to the sapping action of small glaciers. It seems probable that there are small rock basins that were formed by ice erosion in places along the main creek. It seems improbable that preglacial gravels, which if present would be likely to carry placer gold, occur in the bottoms of the buried channels, but this point has not been definitely proved. Since the present stream gravels are derived, for the most part, from erosion of the glacial drift, they contain numerous large boulders, especially in the narrow, steep parts of the stream valleys, as in the lower canyon where there has been considerable erosion of the drift and concentration of boulders.

Active mining on the discovery claim (Plate I A) began on July 22 and continued until the first week in October. The method of mining was similar to that used in the early days. The creek was diverted by damming the water and turning it through a cut made alongside the old channel. Sluice-boxes, made from whip-sawed lumber, were set up in the old channel, water being diverted into the boxes by means of a canvas hose, and the gravels down to bedrock shovelled in. Two cuts were made for a distance of 105 feet along the creek in the lower part of the claim, the maximum width being nearly 50 feet. The gold production—the results of the labour of four men—is reported to have been 278 ounces. Mining by a similar method was done on No. 2 below by Messrs. Brun, Gardman, Peterson, and Cook. A cut was made through the whole claim and about 10 feet of the adjoining claim, the gold production being 85 ounces. Prospect pits were sunk to bedrock on No. 3 below, but no mining was done. No. 1 below was reserved for disposal of tailings. On No. 1 above a cut 200 feet long and 30 feet wide was made by Messrs. Stewart, Bower, and Hendrie, the gold production being 57 ounces. Taking the average value of the gold as $18 an ounce—probably a slightly too high average—the total value of the gold mined from 565 feet in length of the creek was $7,560 or $13.38 a running foot of channel. In the section of the creek from the mouth up to No. 2 above, there remains about 1,400 feet of channel which probably contains about the same or somewhat higher average values. Some gold was found on several of the claims in the upper parts of the creek, but apparently not in sufficient quantities to pay for working by hand methods. On No. 20 above on Dome creek a 2½-ounce nugget was found, but only about 1½ ounces in addition for the season's work.

The possibilities of successful mining on the creek by hydraulicking or by some other method, other than by hand methods which yield only small returns, depend on the amount and character of the payable ground and the available water supply. Judging by the average value of the ground already worked, the 1,400 feet of channel would contain $18,000 to $19,000. The average depth of the ground is about 4 feet and the average width about 30 feet. There is known to be some gold in places along the sides of the creek in the mined part and the average values in the unworked part of the discovery ground are probably greater than on the claims above and below. The gold recoverable by hydraulicking would, therefore, probably exceed $19,000 by a considerable amount. The value of the ground for hydraulicking in the upper parts of the creek and on the tributaries is not known, as nearly all the prospecting was done in attempts to find a definite pay-streak and not to determine the average value of the ground. It is evidently much less than on the discovery ground, but the depth of the ground is much greater. Water can be made available for hydraulicking only for the part of Goldpan creek up to the mouth of Grady creek and the lower part of Dome creek. Taking all this ground into consideration, as well as the 1,400 feet in the lower part of the creek, it appears doubtful whether the gold values are sufficient to justify the installation of an hydraulic plant. In hydraulicking, a ditch about 4,000 feet long, coming from the junction of Grady and Goldpan creeks and crossing Dome creek, would be required. It would give a head on the discovery ground of about 200 feet. In a wet season such as 1925, the water available, including that of Dome creek, would amount to possibly 500 inches throughout the season. In dry seasons it would be much less. Mining of any of the ground with a drag-line scraper or with a steam shovel is scarcely feasible because of the presence of numerous boulders in the deposits and because of the high cost of getting heavy machinery into the area. It is probable, therefore, that further mining can be profitably done only by hand methods, unless an hydraulic plant can be very cheaply installed by utilizing material already in the district and operating on a small scale at times when a good supply of water is available.

The source of the gold on Goldpan creek is not definitely known. The gold occurs most abundantly in places where the surface gravels extend down to the true bedrock in the bed of the stream. The chief concentrations are in the lower 1,400 feet of the creek where the valley is narrow and has fairly steep rock sides. In places in the upper parts of the creek and tributaries, where clay occurs beneath the surface gravels, there are many small concentrations of gold on or in the upper part of the clay, but no gold beneath the clay. The pay-streaks, therefore, are postglacial and have been formed by concentration from the glacial drift. The placer gold itself, however, was probably released from the bedrock by weathering before the advent of glaciation and was concentrated in one or more pay-streaks which were later destroyed or partly destroyed by the glaciers. Just where the preglacial pay-streaks lay is not apparent. Glacial striæ in the vicinity of the creek show that the ice-sheet moved nearly due south. It is probable, also, that during parts of Pleistocene time valley glaciers moved down the creek valley from the mountain slope above. In the lower part of Dome creek there are a great many quartz boulders from which sulphides appear to have been leached, and a piece of "float" quartz containing gold was found near the mouth of the creek by one of the prospectors. This find led to the staking, in the spring of 1925, of a number of mineral claims. The quartz boulders show that quartz veins, from which the gold originally came, probably occur in the upper drift-buried parts of the creek basin. It may be that the main pay-streak formerly existed in the lower part of Dome Creek valley and that the gold became mixed with the glacial drift as the result of glaciation and was reconcentrated to some extent by the Recent streams.

CASTLE AND SQUAW CREEKS

These creeks flow into Little Eagle river from the east. Their mouths are only 1,100 feet apart and are about 1½ miles south of Goldpan creek. Squaw creek is much the larger of the two. It flows northwest in a comparatively narrow rock canyon for three-fourths mile in the lower part, and above occupies a broad, drift-filled valley trending west. The rock canyon is in part at least post-glacial and there is probably a drift-filled, old channel extending downstream from the lower end of the broad, drift-filled, upper part. Castle creek flows in a rock canyon which is steep and narrow for one-fourth mile up from the mouth, but has a comparatively wide, flat bottom and low gradient in the part above. An unusual feature is the occurrence of a mass of calcareous tufa about 12 feet thick which extends nearly across the valley bottom in the form of a dam about one-fourth mile above the mouth. The valley bottom at the "dam" is nearly 300 feet higher than the flat of Little Eagle river at the mouth of the creek. The tufa contains numerous impressions of wood and is evidently post-glacial in origin. It was probably formed by springs that no longer exist or issue at lower levels.

Considerable staking was done on both creeks at the time of the Goldpan rush. A small amount of prospecting was done during the past season, but no gold appears to have been found.

LITTLE EAGLE RIVER

This stream heads in a low divide about 2 miles south of Goldpan trail crossing and flows north in a broad, flat-bottomed valley, to join Eagle or Big Eagle river about 14 miles below the mouth of Goldpan creek. A short distance below the trail crossing the creek disappears into a cavern in limestone. Lower down there are numerous springs along the sides of the valley and deposits of calcareous tufa at the mouths of most of the tributary streams. A small lake, 1,100 feet long, occupies the valley bottom about 1 mile north of the trail crossing. The river, at the mouth of Goldpan creek, is about 25 feet wide and 6 inches to 1 foot deep at an average stage of water. Near the junction with Eagle river it is nearly 100 feet wide and 1½ feet deep. The river has a fall of 90 feet from the trail crossing to the mouth of Goldpan creek, a distance of nearly 4 miles. In the next 5 miles there is a fall of 160 feet. The stream has a fairly even gradient throughout and there are no falls or rapids, although the current is swift and the stream is not navigable. Bedrock outcrops in the bed of the stream only at one place, at a sharp bend about 5 miles below the mouth of Goldpan creek. There is, however, a rock canyon, only a little wider than the river, about 2 miles below the mouth of Goldpan creek. The valley flat continues throughout nearly the whole length of the stream and averages 300 to 500 feet in width. Opposite the mouths of tributary streams, where, as a rule, alluvial fans occur, it is somewhat wider. The valley flat is not timbered except in places below the mouth of Goldpan creek. The deposits of the flat consist of glacial deposits and at the surface recent alluvium including sands and gravels and swamp deposits. The depth to bedrock is not known. Bedrock outcrops in the valleys of the tributary streams near their junction with the main stream, but these valleys are very steep in their lower parts and appear to be hanging with respect to the main valley which may be overdeepened in places by ice erosion.

About 6 miles of the valley flat, above and below the mouth of Goldpan creek, was staked in the spring of 1925 as dredging ground, by Walter Julian, Larry Canty, and others. It is proposed to drill the ground to determine the depth and gold values. Facts which indicate that the ground may prove of value for dredging are: its large extent and uniform, apparently easily dredgible character; its situation within an area where at least one of the tributary streams is known to be gold-bearing; and the occurrence of small quartz veins carrying sulphides—from which placer gold may have been derived—in places along the banks of the river, for example nearly opposite the mouth of Castle creek. On the other hand the valley trends in the direction in which the ice-sheet moved and, therefore, may have been eroded to some extent by the ice, which, if so, precludes the possibility of a preglacial pay-streak occurring in the valley bottom. Some gold, however, may occur in the glacial gravels partly filling the valley and the question of the value of the ground can probably be determined only by drilling.

EAGLE RIVER

Eagle river above the junction of Little Eagle river is about one-third larger than the latter. In the section from 1½ to 3 miles above the junction it flows in a narrow, steep-sided rock canyon about 150 feet deep. About mid-length of the canyon cemented gravels outcrop at the water's edge on the south side. They appear to rest on bedrock slightly below water-level, are 10 to 15 feet thick, and are overlain by basaltic rock—apparently one or more flows—10 feet or more in thickness, which is again overlain by glacial drift. It is not known whether the gravels contain any gold and in any case they would be difficult to mine because of their cemented character. They may be cemented, however, only near the outcrop. The old channel of the river appears to lie somewhat to the south of the present stream. The present channel is post-glacial and the stream was forced to cut it because of deposition of lavas and glacial drift in the old channel.

Above the canyon the river and its main tributaries for long distances occupy broad, flat-bottomed, drift-filled valleys with comparatively low gradients. Some of the tributaries head in immense glacial cirques in Cassiar mountains and it is evident that there has been a great deal of glacial erosion in the headwater parts of the river basin and probably also in the broad parts of the main valley above the canyon. No gold is known to have been found in these parts of the river basin, though, probably, prospecting has been done at only a few places. Because of the effects of glacial erosion, pay-streaks in the broad parts of the valley and its tributaries would be likely to occur only in the surface gravels and such pay-streaks would easily have been found if they existed in important quantities. The gravels buried beneath lavas and glacial drift appear to offer the best opportunities for the prospector. A small area of these occurs also in the bottom of the comparatively deep, narrow valley entering the river from the northwest about 1 mile above the canyon. The valley contains three beaver ponds near its summit, one of which drains northeast into Eagle river. The gravels outcrop near the lower end of this pond.

The river, for 8 miles below the mouth of Little Eagle river, down to where it enters Cassiar mountains, flows in a broad, drift-filled valley, along the sides of which terraces are cut in the drift deposits up to heights of 5 to 50 feet above the stream. Throughout the greater part of this stretch there are cut banks of drift deposits and occasionally rock outcrops on one side or the other of the river, and opposite the cut banks are low, broad, alluvial flats. The stream averages nearly 150 feet in width and 1 to 3 feet deep, and is in places split up into several channels. Bedrock outcrops across part of the bed of the stream and a rapid occurs at one place about 4 miles below the junction. The grade of the stream is fairly even and the current is swift. During the freshet the water rises 3 to 4 feet above the low-water stage, or nearly to the level of the lowest terrace. The depth to bedrock in the channel is unknown. The absence of rock outcrops seems to show that it is considerable. There are numerous gravel bars and, in places, accumulations of boulders in the bed of the stream, but most of the material consists of sand and gravel. Very little gold is reported to have been found on the bars along this stretch of the river, so that it does not appear very attractive as a dredging proposition, probably the only way in which the ground can be mined.

In the Cassiar Mountains stretch of the river, the valley, for the most part, is fairly broad and deep, but is much narrower than that of Dease river. The valley bottom is filled with glacial drift and alluvial deposits and averages nearly one-fourth mile in width. In places the steep, rocky sides extend down nearly to the water's edge, on one side or the other, and in places rock "islands" occur in the valley bottom. There are no falls or bad rapids, and the stream has been ascended by small boats, but navigation is difficult because of the swift current and numerous boulders and shallows on the bars. The tributary streams have very steep gradients and very bouldery beds. The larger ones head in glacial cirques. No paying deposits of gold are reported to have been found on the bars in the mountain section of the river. Little prospecting, probably, has been done on the tributaries, but their steep gradients, the bouldery character of their beds, and the highly glaciated character of the area, are not favourable features. The areas underlain by granitic rocks appear to be specially unfavourable. In other areas where the rocks are mineralized to some extent, for example in the first large stream valley entering from the west below where Eagle river enters the mountains, there may be some chance of finding post-glacial pay-streaks in the beds of the streams.

DEASE CREEK

Dease creek (Figure 4) flows into Dease lake from the southwest about 16 miles from the head of the lake. It is about 60 feet wide and 1 to 2 feet deep at low water. During the freshet the water rises 2 to 3 feet. The delta and alluvial fan at the mouth of the creek are of small areal extent because of the great depth of that part of the lake basin into which the delta has been built. The part of the delta and alluvial fan southwest of the road leading upstream from the site of the old town of Laketon is above lake-level and was formed when the lake stood at a higher level. The old delta or alluvial deposits rest on glacial drift and terraces are cut in the drift deposits at various elevations up to over 100 feet above the lake. The terraces were probably formed by ice-border drainage waters, for they are discontinuous and their surfaces are marked in places by potholes, apparently formed by the melting of ice blocks included in the drift. The raised delta deposits were probably formed during the closing stage of glaciation, when the lake basin was still occupied by ice.

The stream issues from a short length of rock canyon at the inner edge of the alluvial fan, where it has an elevation of 16 feet above the lake. The nearly vertical sides of the canyon show that it is post-Glacial in age. The depth to bedrock in the bottom of the canyon is said to be 18 to 25 feet. A short distance outside the mouth of the canyon the bedrock drops off abruptly into the basin of the lake, as is shown by borings, and as is to be expected on theoretical grounds, because of over-deepening of the lake basin by ice erosion. The depth to bedrock in the bottom of the canyon may be accounted for by the fact that it was possible for the stream to erode its channel slightly below lake-level, before the alluvial fan was built to its present height. At the first bend above the canyon, on the northeast side, is a drift-buried channel, marked by three tunnels (Figure 4), which is probably an old channel of the creek. The bottom of the channel at the tunnels is 35 feet above the lake. The channel is filled with drift to a maximum depth of about 100 feet. The place where it issues on the lake front is not known.

Rock benches buried beneath drift occur on the northeast side of the creek at the mouth at elevations of 50 to 100 feet above the lake and mark old channels of Dease creek formed at a time when the creek flowed at higher levels than it does now. Extensions of the old channels in the form of drift-covered rock benches occur at intervals along the creek for 8 miles upstream. The old channels, for the most part, however, have been destroyed by the stream erosion that produced the present valley.

The valley above the canyon at the mouth is narrow, fairly steep-sided, and about 300 feet deep. Bedrock outcrops in the bed of the creek at many places and, for 8 miles upstream, there is comparatively little drift or alluvial filling in the bottom of the valley. In places the stream flows in a rock canyon with nearly vertical sides, but, for the most part, the rock sides are sloping or are in the form of benches and are covered with glacial drift and slidden material. The rock benches marking old channels of the creek occur mostly as small remnants on one side or the other of the creek. The longest stretch, about 1,700 feet, is on the southwest side at the McCrimmon tunnel, 1½ miles up the creek, where the bench is 85 feet above the level of the creek. Another fairly long stretch is at the Brian-McKay's workings on the same side 2½ miles upstream. Above the trail crossing, 5½ miles upstream, most of the benches are on the northwest side. The highest series of benches, which is the strongest, has about the same gradient as the present stream in the part below the McCrimmon tunnel and a somewhat less gradient in the part above. The total fall in the creek from the trail crossing to the lake is 540 feet. The gradient is fairly even, but rapids and slight falls occur at a few places.

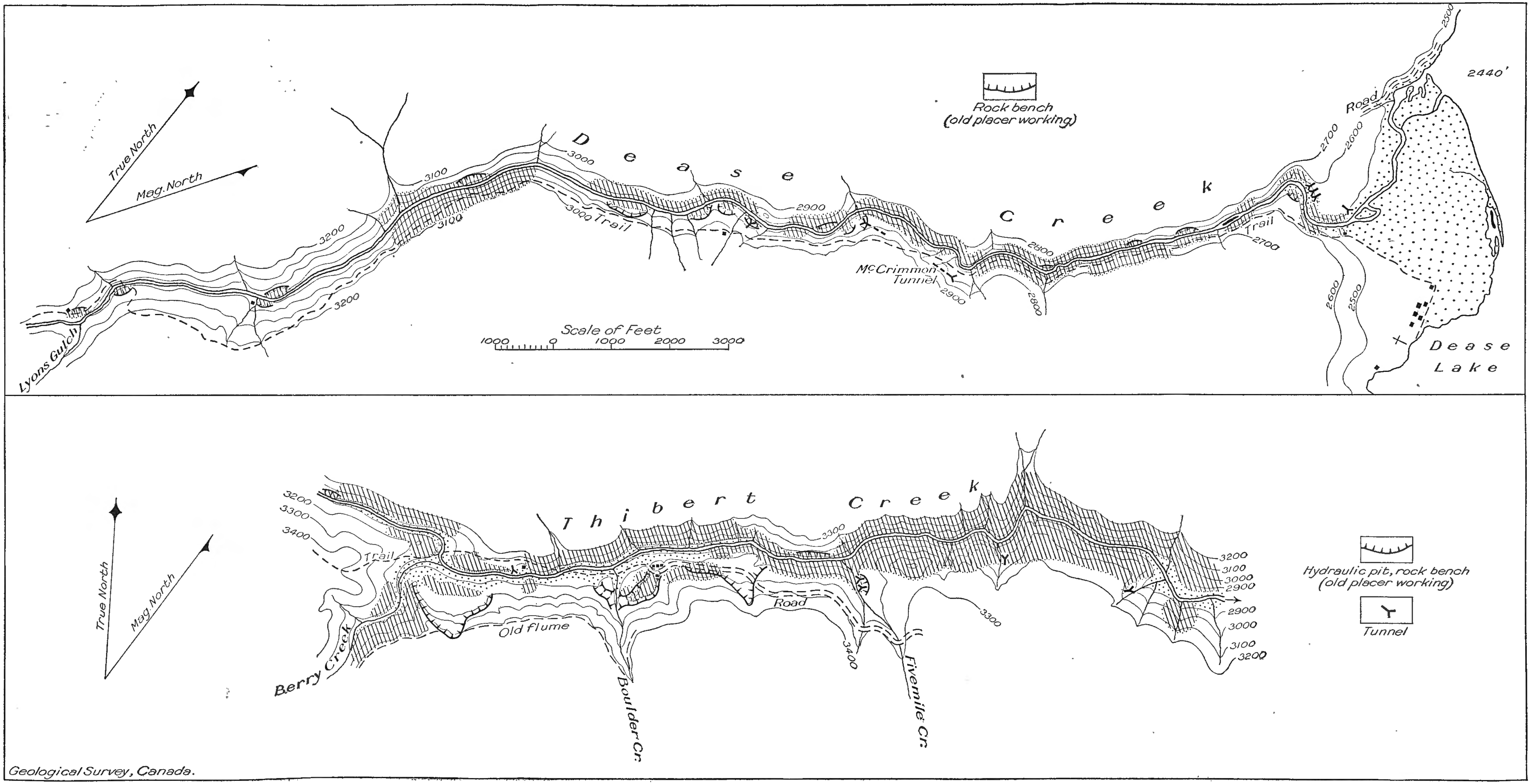

FIGURE 4. Parts of Dease and Thibert creeks, Cassiar district, B.C. Areas where bedrock outcrops are shown by a pattern of parallel lines; areas of Recent alluvium by a pattern of dots; areas without a pattern are occupied by glacial drift.

The stream is not navigable. A good pack trail extends up the creek about 8 miles and a road starting at the lake on the north side of the delta is under construction.

The geological history of the creek appears to be as follows: in pre-Glacial time the stream flowed at the level of the highest rock bench nearly 100 feet above the level of the present stream in the lower part and only slightly above the creek in the upper parts. In this old stream valley there were concentrations of placer gold derived from the wearing away of a considerable thickness of the country rock which contained, somewhere in the creek basin, gold-bearing veins. Later the stream was rejuvenated by uplift or by deepening of Dease Lake basin by ice erosion. The stream cut down its channel to the level of the buried channel at the mouth. This down-cutting, as already pointed out (page 48) probably took place in interglacial time, when the ice-sheet had temporarily melted away. The ice-sheet advanced across the valley and filled or partly filled it with glacial drift. A valley glacier did not move down the valley because it trends nearly at right angles to the general direction of ice movement and there was no large gathering ground for a local glacier at its head. The valley, therefore, was only slightly eroded by the ice. After the final disappearance of the glaciers the stream re-excavated the valley and cut down in places a few feet into the bedrock in the bottom. The placer gold found in the bottom of the valley was derived by erosion of the glacial drift with which it had been mixed and to some extent by erosion of the pay-streaks on the old benches. The gold on the benches is mixed with the glacial drift, but probably there are or were in places before mining was done, remnants of the original pay-streak.

Mining on Dease creek began in 1874 and was carried on for many years. The standard method was by diverting the creek by means of wing-dams, and sluicing the materials down to bedrock and thoroughly cleaning the bedrock. The rich spots were where the old channel had been cut away by the present channel; the barren places were opposite the stretches where the old channel is intact, as opposite the McCrimmon ground. Bedrock in the rich parts of the creek bottom for 6 to 8 miles upstream is said to have been cleaned at least a dozen times since 1874. The harvest in the first two years of mining was, of course, the richest, but as the stream is constantly eroding its banks small amounts of gold are concentrated annually and small areas of virgin ground were overlooked in the early days. The final operations, however, did not pay and for many years the bed of the creek has been regarded as mined out. The lowest wing-dam on the creek was about 150 feet above the upper end of the rock canyon at the mouth. Part of the ground in the canyon is said to have been mined by drifting.

Mining of the benches by drifting and by open-cuts began in 1874 and has continued at intervals to the present time. The most notable work was on the McCrimmon ground where nearly the whole length of the bench was drifted. Very good results are reported[1] to have been obtained. Considerable drifting and open-cut work was done on the Brian-McKay ground 1 mile farther upstream and at California bar,

[1]Nichols, H. G.: "The Cassiar Goldfield"; Can. Min. Jour., March 28, 1924, p. 296.

the old Cariboo Company's ground, about 8 miles upstream from the mouth. Some drifting has been done by George Johnston and others in recent years on a bench on the north side at the bend above the trail crossing. Two tunnels were run and some drifting done a number of years ago in the buried channel above the canyon at the mouth of the creek, but the work was discontinued apparently because it did not pay. A third tunnel which broke into the old workings was recently run by the Dickinson Mining Company. The channel is filled with boulder clay and glacial gravels. Its bottom cannot be reached by hydraulicking from the lake side end—the location of which, however, is not known—as the gradient is too low.

The total gold production of Dease creek, from 1874 to 1895, was nearly $900,000[1], which amount is not very large, considering the length of the productive part of the creek, nor does it compare favourably with the production of several of the creeks in Cariboo, B.C.

The chief interest in the creek at the present time lies in the possibilities of hydraulicking the benches, and mining the ground in the bed of the creek at and near the mouth. In September, 1925, the Dickinson Mining Company of Seattle completed the installation of a drag-line scraper mining plant in the canyon at the mouth of the creek and expected to operate the plant for a few days before the close of the season. The ground in the canyon and in the delta below had previously been drilled to determine the depth and gold values. In all, thirty-one borings were made, eleven by W. M. Ogilvie in 1913, thirteen by F. W. Craig in 1924, one by F. Suel, and three by the Dickinson Mining Company. Some of the borings were in the canyon, but most of them were scattered over the delta flat below the canyon. There is a stretch of about 900 feet of the creek from the lowest old wing-dam just above the canyon down to where the stream issues on to the flats, in which the average value of the ground is said to be about one dollar a yard. Taking the average width of the pay as 50 feet and the average depth as 18 feet, this stretch would contain 30,000 yards. The average value of the ground in the delta is reported to be much less than in the canyon of the creek, and it is doubtful whether it is sufficiently rich to pay for mining. The gold probably extends downwards only slightly below lake-level and there is probably little or no gold in the outer parts of the delta. Moreover, there would be difficulties in mining the delta ground because of the presence of buried timber.

The Dickinson Mining Company also propose to mine by hydraulicking the bedrock benches overlain by drift on the northeast side of the creek at the mouth. The benches were mined to some extent by drifting in the early days, but whether the work paid and what is the average value of the ground is not known. Water for hydraulicking would have to be obtained from Dease creek. In order to obtain a head of say 200 feet a ditch or flume about 2½ miles long would be required. A flume would be necessary for considerable distances because of the steep sides of the creek. It seems doubtful whether the benches, unless they prove to be of exceptional richness, are of sufficient extent to justify the installation of an hydraulic plant and the construction of a ditch or flume.

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[1]Ann. Repts., Minister of Mines, B.C.

The McCrimmon bench, together with the benches one mile upstream on the same side, form the largest area of possible hydraulic ground on the creek. The McCrimmon ground is held under separate lease. A small hydraulic plant is being installed on the benches above (Sunrise lease) by Thomas Brian and Angus McKay. Water for hydraulicking in both areas will have to be obtained by a ditch from Lyons gulch, and about 3 miles long or 4 miles to the lower end of the McCrimmon ground. The Lyons Gulch stream has a low water flow of only about 300 miner's inches, but water can be diverted into Lyons gulch from Buck gulch, a much larger stream, by a ditch about 2 miles long. A water supply of possibly 1,000 miner's inches would thus be obtainable under a head at the hydraulic pit of 300 to 500 feet. Facilities for disposal of the tailings are good because of the height of the benches above Dease creek. The results of hydraulicking on Thibert creek showed that, under conditions existing in the district, and using 1,000 miners' inches of water under a head of 300 feet, 300,000 to 400,000 yards can be handled in one season, but the average would probably be less. The average value of the ground on the benches is not known and will be very difficult to determine unless thorough drilling be done. The owners hold that the drifting and open-cut work show that the ground contains fairly high values. It may be, however, that most of the gold is in the basal gravels which were mostly drifted out. There is known to be some gold in the glacial drift that fills the channel. Hydraulicking on Thibert creek showed that the ground is easily affected by slides because of the steep sides of the creek and because clay overlies water-bearing sands and gravels. Similar conditions exist on Dease creek. The central part of the McCrimmon channel contains over 1,000,000 yards of dirt, but it is probable that at least 3,000,000 yards would have to be hydraulicked in order to clean out the bottom of the channel. It is necessary, therefore, to take into consideration the average value of all the ground that must be moved in order to reach the bottom of the channel. It appears to the present writer that the benches on the Sunrise lease are not sufficiently large to justify any large expenditure for an hydraulic plant, but that these, together with the McCrimmon ground, are well worthy of further investigation as an hydraulic proposition on a fairly large scale. In undertaking such a work the difficulties met with and the mistakes made in hydraulicking on Thibert creek, which are briefly referred to in this report (page 66), should be taken into consideration.

The Dease Creek Mining Company, Limited, Seattle, Wash., of which J. Blick is manager, hold seven leases in the upper part of the creek, and are installing an hydraulic mining plant on the north side of the creek about 8 miles above the mouth. It is proposed to bring water about 4½ miles from Little Dease lake, a good supply, probably at least 1,500 inches, being available. About 30 tons of hydraulic pipe, a caterpillar tractor, and other mining machinery were taken into the area in 1925 and a road up the northeast side of the creek partly constructed. The ground to be mined has been tested in places by tunnels and by open-cuts and is said to carry good average gold values. It consists of drift-covered rock benches, 20 to 30 feet above the creek, which were partly drifted and mined by open-cut work in the early days. One bench is on the south side of the creek just above Bucks gulch. Another is on the north side about three-fourths mile upstream. A third, which, however, has been largely cleaned off, is on the north side between Bucks and Lyons gulches. The benches are probably the upstream continuations of the McCrimmon channel. They were not specially examined and the extent of the minable ground by hydraulicking is not known. A difficulty is that the benches occur on both sides of the creek and are not very extensive at any one locality. Facilities for disposal of the tailings are not so good as lower down on the creek because the benches are considerably lower. G. M. Dawson[1] stated regarding mining in the early days on the upper parts of the creek, "a few isolated good claims were found, particularly the Cariboo Company's claim, 8 miles up, from which much heavy gold was obtained. This claim has been worked over four times."

THIBERT CREEK

Thibert Creek delta (Figure 5) is much larger than that of Dease creek, although the creek is only a little larger, the reason being that the delta was built into the valley at the foot of Dease lake, which was already partly filled with glacial drift. Two "islands" of glacial drift occur in the delta and rise 50 to 100 feet above the general surface. The inner part of the delta is in the form of an alluvial fan, the highest part of which, where the creek issues from a rock canyon, is 46 feet above the lake. There is a drift-buried channel of the creek on the south side of the canyon, that probably has nearly the same depth as the present channel and is separated from it by low rock outcrops. It leaves the present channel about 800 feet upstream from the mouth of the canyon. The ground in the present channel in the canyon as shown by borings has a maximum depth of about 35 feet. There is a drift-covered rock bench on the north side at the canyon that is nearly 200 feet above the level of the creek and marks an old channel of the creek where it flowed at a much higher level. This old channel is cut off abruptly by the deeply eroded Dease Lake valley. Rock benches 5 to 50 feet above the level of the creek occur in places on one side or the other up to the mouth of Deloire creek. In this stretch the highest rock bench has been mostly cut away. The rock benches, even the lowest, are or were, before mining was done, covered with at least a thin veneer of glacial drift.

The part of the creek valley (Figure 4) between the mouth of Deloire creek and the mouth of Berry creek 8 miles upstream is, for the most part, broad and 300 to 500 feet deep. Rock benches marking the old high-level channel are continuous along the south side for long distances (Plate I B). Small remnants of the old channel occur on the north side about one-half mile above the mouth of Deloire creek, and just above the mouth of Fivemile creek. The old channel has a lower gradient than that of the present stream. At the mouth of Berry creek the old channel is 90 feet above the level of the creek; one mile below the mouth of Fivemile creek it is 190 feet above the level of the stream. In the lower part of the creek, where there are only a few remnants of the channel, the gradient is about the same as that of the present stream. The old channel crosses a rock point near the creek just above the junction of Berry creek and farther upstream

[1]Geol. Surv., Canada, Pub. No. 629, p. 77.

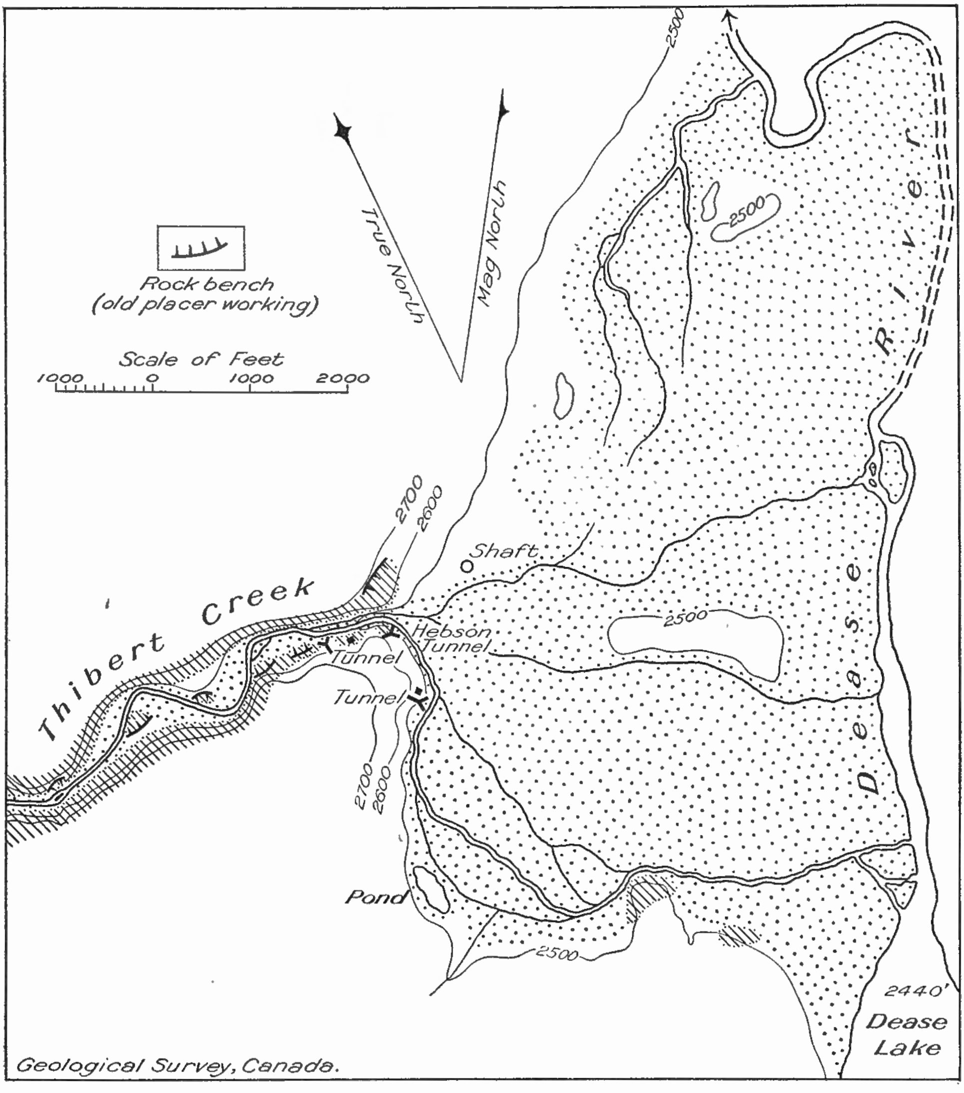

FIGURE 5. Thibert Creek delta, Cassiar district, B.C. Areas where bedrock outcrops are shown by a pattern of parallel lines; areas of Recent alluvium by a pattern of dots; areas without a pattern are occupied by glacial drift.

gradually descends to near the level of the present stream, but is mostly cut away. Small remnants occur on the north side ½ to 1 mile above the junction of Berry creek. The old channel has been hydraulicked out for 1,000 feet downstream from the mouth of Berry creek, at the mouth of Boulder creek, and for 2,500 feet downstream from this creek. The longest, continuous, preserved stretch of the old channel is below the mouth of Fivemile creek where it extends behind a high, rounded rock hill and continues down stream nearly parallel to the present creek. It appears to come out into the present valley near an old cabin on a forked creek 1½ miles above the mouth of Deloire creek. If so, the stretch is about 4,600 feet long. The part of the present stream valley opposite the buried channel is a narrow, deep, rock canyon. The old channel was mined over in part, if not throughout its length, by drifting. The old mine at the upper end of the channel was known as the Blue Bell.

The geological history of the creek is probably very similar to that of Dease creek as already recounted. The fact that the old stream channel of Thibert creek where it is cut off abruptly by Dease Lake valley is 200 feet above the level of the lake, whereas that of Dease creek is only about 100 feet, seems to show that the main stream in Dease Lake valley flowed south, that is the drainage in the main valley into which the ancient streams of Dease and Thibert valleys flowed was in the opposite direction to what it is now. The facts that the rock bottoms of the present streams at their mouths, as well as the old high-level channels, are hanging with respect to the main valley and that Dease Lake basin has a maximum depth of nearly 400 feet show that nearly all the deepening of the main valley below the present lake-level was probably due to glacial ice erosion. If the valley had been formed by stream erosion it must have had an outlet as low as the deepest part and the tributary streams would have been at least fairly evenly graded to the bottom of the valley. But the valley is only a mile wide, so that the tributary streams would have extraordinarily steep gradients in their lower parts. It seems improbable that there is any drift-buried outlet channel as low as the deepest part of the lake basin, although this is not definitely known. In any case it is possible that the buried channel at the south end of the lake, which extends through to Tanzilla valley, was also deepened by ice erosion. All the stream valleys tributary to Dease Lake valley are hanging with respect to the main valley, but some of the streams tributary to Dease River valley, for example Beady creek a short distance below the foot of the lake, are graded to a somewhat lower level than the present valley flat. These valleys are mostly in Cassiar mountains and may have been overdeepened by valley glaciers. Deepening of the main valley by stream erosion would have caused the tributary streams to be graded to the bottom of the main channel; ice erosion of the main valley would have left them hanging as they are. The only other possible cause for the overdeepening of Dease Lake valley is faulting. There is no evidence of faulting at the mouths of Dease and Thibert creeks and it is very improbable that faults occur along both sides of the lake and were of such character that downfaulting of the whole lake basin occurred so uniformly.

The main significance of these partly hypothetical considerations, so far as the occurrence of placer gold is concerned, is that rich pay-streaks are not likely to occur in the bottoms of the glaciated river valleys and that bedrock in the deltas of the creeks is likely to be at a considerable depth. On the other hand there is the remarkable fact that the old high-level channel of Thibert creek is preserved for considerable stretches in spite of the effects of glaciation. The bedrock in the new channel is fresh, whereas that of the old channel is deeply weathered, and in places in the bottom of the channel partly cemented gravels occur, which are probably preglacial in age. The old channel was partly filled with glacial drift and as pointed out in the case of Dease creek was protected from erosion by the ice, because the glaciers moved across and not down the valley. That the old channel is the source of most of the placer gold on the creek is shown by the fact that no paying deposits of gold were found in those parts of the present creek alongside of the stretch where the old channel is intact, but were found in the parts where the channel has been partly or entirely cut away by the present stream.

The total production of gold from Thibert creek is about the same as that of Dease creek. Very little gold was found on the stream above the mouth of Berry creek, and unlike Dease creek most of the production was from the benches or old channels. Bedrock is exposed in the bed of the creek at only a few places. There is now a considerable filling of tailings in most parts of the creek below the mouth of Berry creek and even on the delta. The ground, before hydraulicking began, was somewhat deeper than on Dease creek and it is an open question how much of the bed of the stream was mined by wing-damming. It is probable that most of the rich parts were mined in this way, but there is a short stretch in the canyon at the mouth and above it which may not have been mined because of the volume of water in the creek even at low water. The creek appears to be as large—8 to 10 miles— upstream as it is at the mouth and it is probable that there is a considerable underground flow of water in the lower part.

The absence of placer gold in the upper parts of the creek above the mouth of Berry creek is probably due to two factors: (1) the gold was derived locally and the bedrock in the lower part of the creek valley contained more gold-bearing veins than in the upper parts; and (2) a valley glacier moved down the valley nearly to the mouth of Berry creek and transported downstream or mixed with the glacial drift any old placers that existed in the upper parts of the creek.

Mining by drifting of the buried channel on the south side of the canyon at the mouth of the creek (Figure 5) is being attempted by Thomas Hebson and William Noel. The upper part of the ground was drifted in the early days from the White tunnel. An inclined tunnel at Hebson's cabin 1,000 feet south of the mouth of the canyon was run, but did not reach the channel. An attempt by Hebson to deepen the incline failed because of water pressure. At present an inclined tunnel is being run just south of the rock rim of the channel at the mouth of the canyon. During the freshet the workings are flooded. It is proposed to install a pump to drain the ground. Whether the ground can be drained sufficiently to permit of mining depends on whether the materials between the channel and the creek are sufficiently impervious to prevent rapid inflow of the creek water. The materials filling the channel are glacial sands and gravels with some silt and clay. The part of the channel that remains to be mined is 300 to 500 feet long; the part that was mined is said to have yielded well. A shaft 1,000 feet northeast of the tunnel was sunk 31 feet by Hebson, but no pay gravels were found.

The delta flats and the lower part of the creek are held under dredging leases by the Cassiar Dredging Company, Limited. In 1913 three borings to determine the depths and value of the ground for dredging were made by W. M. Ogilvie. The deepest of these holes, which was located about 500 feet upstream from the mouth of the canyon, is said to have been 33 feet deep and to have shown values of 60 cents a yard. The other two are reported not to have reached bedrock, but to have shown about the same average values. There is a stretch of the creek 5,300 feet long from the mouth of the canyon up to where the rock rims of the creek are only 65 feet apart. Taking the average width of the pay in this stretch as 100 feet, the average depth as 27 feet, and the average value as 60 cents a yard—probably much too high averages—the total value of the ground would be $318,000. The ground, therefore, is not sufficiently extensive to justify the installation of a dredge. There is a large area of ground in the delta which probably contains a little gold. The results of borings in the Dease Creek delta, however, do not favour the view that the ground is rich enough to pay for dredging. Moreover, there would be difficulties in dredging because of the presence of buried timber. Deltas and alluvial fans are not very favourable places for the occurrence of paying deposits of placer gold, for only the gold fine enough to be transported by the stream is deposited, the stream tends to shift its course from one part of the fan to another so that there is little opportunity for concentration of the gold by erosion of the deposits, and practically no gold is deposited below the level of the water body into which the delta is built. All the gold in Dease and Thibert Creeks deltas has been deposited post-glacially and because of the short period of time involved—only a few thousand years—and the lack of extensive erosion of the stream channel, it is not to be expected that paying deposits occur in the deltas, except possibly near the heads of the alluvial fans.

Mining in the stretch of the creek valley from the mouth of Fivemile creek to the mouth of Berry creek (Figure 4) has been done by hydraulicking on a fairly large scale and by drifting in the early days. Practically the whole of the old channel on the south side of the creek in this stretch has been hydraulicked out. The part of the channel (described above) below the mouth of Fivemile creek forms the only remaining hydraulic ground of importance on the creek, except that at the mouth of Deloire creek. The channel at the summit opposite the high, rounded hill 1,000 feet below the mouth of Fivemile creek is filled with glacial drift to a maximum depth of about 215 feet. Much of the material at the surface is boulder clay; but no good sections are exposed. Judging by the sections in the old hydraulic pits it is probable that the boulder clay is of no great thickness and is underlain by glacial gravels. The average gold values in the ground are not known, but the drift mining in the early days is said to have paid well and, therefore, it is generally held that the ground still contains considerable gold. In attempting to determine whether the ground is worthy of investigation as an hydraulic proposition it is important to consider the history of hydraulicking of the nearly similar ground higher up on the creek.

Hydraulicking by several companies was done during fifteen seasons, or parts of seasons, from 1901 to 1922. Water from Berry creek, amounting to about 500 inches, was obtained at first. This proved insufficient and in 1906 additional water from the second fork of French creek and from the second tributary of the north fork of Dease creek was diverted into Berry creek by a ditch 2 miles long. One of the best water supplies obtainable anywhere in the district, amounting to about 1,000 inches, was thus secured. The total amount of gold recovered was about $160,000 and the total expenditure was at least $250,000. In only a few years did the value of the gold recovered exceed the operating cost, which amounted on the average to about $10,000 a season. Judging by the size of the excavations approximately 3,000,000 yards of ground, including slides, was handled. The average value of the ground, therefore, must have been very small. The manager reported[1] that in 1915 452,777 yards of ground was handled, but the gold recovery was only about $25,000. Testing of parts of the ground, before work was begun, seemed to show that it would average about 50 cents a yard, but the extra amount of ground which had to be put through the sluice-boxes because of slides into the pits was not taken into consideration. It is probable, however, that, regardless of the slides, the average value was considerably less than 50 cents a yard. There were other difficulties. Because of the steep slopes a flume instead of a ditch was necessary for the whole distance from Berry creek, about 3 miles. It proved expensive and difficult of upkeep at first, because of settling when the frost went out of the ground, and later when slides occurred. If an efficient water supply had been obtained in the first place and care taken to avoid the ground susceptible to slides, it is possible that the work would have paid, although the profit in any case would have been very small. The cost of transporting heavy machinery, about $270 a ton from the coast to the mine, was excessive. It is only slightly less at the present time.

The ground in the old channel below the mouth of Fivemile creek, if hydraulicking be attempted in it, probably would be affected by slides to a somewhat less extent than the ground in the old hydraulic pits above, because the channel is enclosed in places by rock sides. The length of the unworked part of the channel is about 1,000 feet longer than the parts hydraulicked out above the mouth of Fivemile creek. In order to make the work pay the value of the ground would have to be considerably higher than in the parts already hydraulicked, which does not seem very probable, but the question can be determined only by systematic drilling. Water for hydraulicking would have to be obtained either by reconstructing the old flume from Berry creek and extending it a mile or more downstream or by a pipe-line or flume from Thibert creek itself. There would be difficulty in reconstructing the flume, because slides have removed it in places and left very steep banks, and because of the scarcity of trees for lumber in the vicinity. The sawmill used by the old companies was, for a time, located on Berry creek, but was removed to the point on the east side of Dease lake above Porter landing, where standing timber was more abundant and where it remains in a partly dismantled condition. Lumber is said to have been produced at the mill at a cost

[1] Ann. Rept., Minister of Mines, B.C., 1915.

of about $40 a thousand feet, but it is doubtful whether it can be produced at present at so low a cost. A pipe-line or flume to bring water from Thibert creek would be at least 4 miles long and would prove very expensive and difficult to upkeep. A fact that may be of significance regarding the question of further hydraulicking is that platinum is known to occur in the placers of the creek. About 2 ounces to the ton of concentrates is reported to have heen obtained in hydraulicking, but the amount of concentrates appears to have been small. It is not known to occur elsewhere in the district.

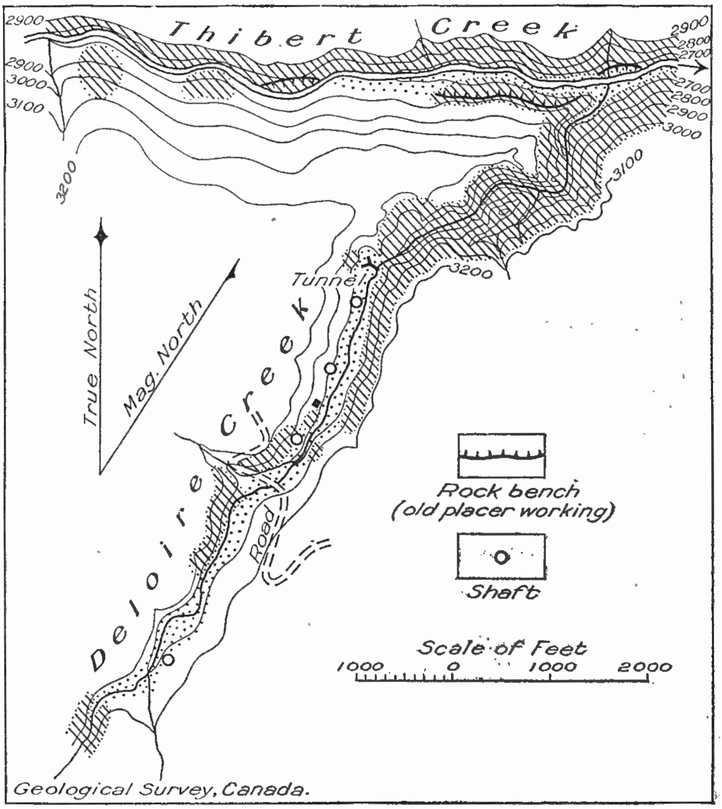

FIGURE 6. Deloire creek, Cassiar district, B.C. Areas where bedrock outcrops are shown by a pattern of parallel lines; areas of Recent alluvium by a pattern of dots; areas without a pattern are occupied by glacial drift.

DELOIRE CREEK

Deloire creek (Figure 6) or Little Deloire creek as it was formerly known, flows north into Thibert creek. The lower part of the creek for 3,500 feet up from the mouth is a narrow, deep, rock canyon, in which the stream has a fall of nearly 250 feet. Above the upper end of the canyon the valley flat widens, and has a comparatively low gradient for about 1 mile upstream where another rock canyon begins. In this stretch the ground is 20 to 30, or possibly in the upper part 40, feet deep. A buried channel of the creek probably extends from the lower end of the wide, flat part of the creek, through to the valley of Thibert creek. The channel is filled with glacial drift to a maximum depth of about 200 feet.

Some mining was done on the creek in the early days and several shafts have been sunk in recent years to mine the ground in the flat above the canyon; but without much success, as the ground proved difficult to mine, because of its porous character, and only low gold values were found. In recent years attempts have been made to reach the bedrock in the channel by using a "shooter" dam or by "booming" of the surface materials, but bedrock in the lower part of the channel is a few feet lower than the rock lip at the mouth of the rock canyon. The ground on the creek is held at the present time by George Ball and the Finn brothers who propose hydraulicking of the buried channel and of the part of the creek above, after the buried channel is cleaned out. Attempts were made in the early days to find the outlet of the buried channel into Thibert Creek valley and several tunnels were run into the south bank of Thibert creek. It appears to the present writer that these tunnels were too low, and that the outlet of the channel is nearly 200 feet above the level of Thibert creek and about 1,500 feet west of the lower part of the canyon of Deloire creek. The average gradient of the bedrock in the creek bottom above the canyon is 3 per cent. If this gradient be continued downstream in the buried channel the bedrock at the mouth would be about 200 feet above the level of Thibert creek and this height is very nearly the level of the old channel of Thibert. If the buried channel occurs at this level, as seems probable, there would be good facilities in the deep valley of Thibert creek for the disposal of tailings, and, as the ground has not been drifted, there is a possibility that it contains good gold values. The water supply available for hydraulicking, however, is small, for the creek itself has a low water flow of only 300 to 500 inches, but it may be that water can be diverted into the headwaters of the creek by a system of ditches leading from other creeks.

MOSQUITO CREEK

Mosquito creek (Figure 7, Plate II A) flows into Thibert creek from the north about 7 miles above the mouth of Berry creek and is reached by wagon road from Porter landing to the old hydraulic mine, 6 miles from the landing, and thence by pack trail. The lower part of the creek for 1,000 feet up from the mouth is a narrow rock canyon in which the ground is a few feet deep, but is very bouldery. There is a rock lip at the mouth which has prevented cleaning out of the rock channel by ground-sluicing. Tunnels driven upstream in the canyon for over 600 feet also failed to reach bedrock, because of the bouldery character of the materials and because of the lack of drainage for the deepest part of the channel. Above the canyon the valley widens and has an alluvial flat averaging about 150 feet in width and an average surface gradient of 3 per cent for 6,000 feet upstream. At the bend 3,000 feet above the head of the canyon there are a number of strong springs which flow all winter and are said to keep the creek from freezing over during the winter.

Some mining was done in the creek in the early days and a long tunnel in the canyon is said to have been the last work of Henry Thibert, the discoverer of gold in the district. In recent years considerable work has been done on the creek by George Adsit. An inclined tunnel, shown on Figure 7, was run, but did not quite reach bedrock. In 1925, H. H. Darud obtained an option on the ground and put down six bore-holes to determine the depths and gold values. The borings are reported to have shown good values and an hydraulic plant for mining of the ground is being installed. The deepest boring, 54½ feet to bedrock, is just below

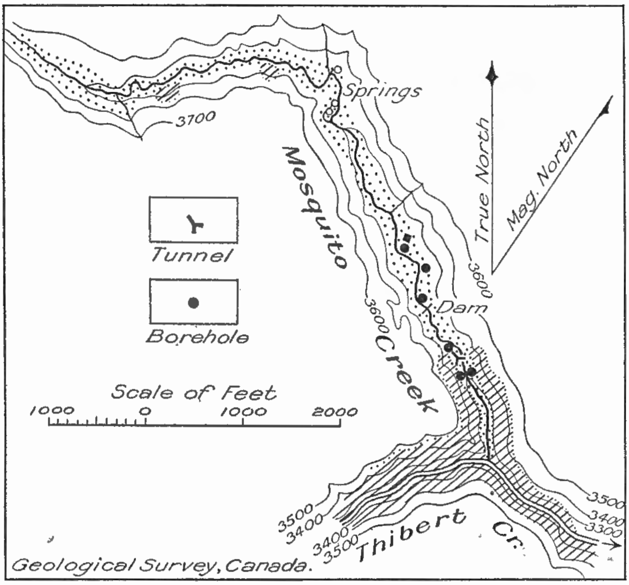

FIGURE 7. Mosquito creek, Cassiar district, B.C. Areas where bedrock outcrops are shown by a pattern of parallel lines; areas of Recent alluvium by a pattern of dots; areas without a pattern are occupied by glacial drift.

the cabin 1,300 feet above the inclined tunnel. The bedrock in the channel from the mouth up to the end of the inclined tunnel has an average gradient of a little over 3 per cent, which is sufficient for hydraulicking. The borings upstream from the tunnel show that the bedrock in this section probably has a very slight gradient downstream. It may be, however, that a shallow rock basin exists in the wide part near the cabin, so that it is doubtful whether the bedrock in this part of the creek can be reached by hydraulicking. Only a small supply of water for hydraulicking, probably not exceeding 500 inches in a wet season, can be obtained from the creek itself, but it is probable that the supply can be materially increased by diverting water from Porcupine lake into the creek at comparatively small cost. The proposed work seems to have a reasonable chance for success, although it does not appear that sufficient borings have been made to determine the extent and value of the ground.

LAVA-BURIED PLACERS

Gravels that are gold-bearing, at least to some extent, occur beneath lavas or (and) volcanic tuffs, in places in Stikine River valley and in the Eagle River country east of Dease lake. The lava-buried river gravels of the Stikine were described by G. M. Dawson,[1] who was of the opinion that the gold found on the bars of the Stikine was derived from these buried gravels. He considered them worthy of investigation as a possible source of placer gold and stated that he could not learn that the old channels had been prospected for gold (prior to 1887)[2]. The lava-buried gravels seen by the present writer along Stikine river between Telegraph creek and the mouth of the Tahltan 12 miles upstream are here briefly described, as well as those in the Eagle River country, because they are of special interest and may have still some possibilities for placer mining, although no important discoveries of placer gold in the old channels appear to have been made since 1887.

Gravels overlain by one or more lava flows occur in the vicinity of Telegraph creek on the north side of the Stikine, along the trail from 1 to 2 miles below the mouth of the Tahltan and at the mouth of the Tahltan (Plates II B and III A). The great canyon of the Stikine (Plate III B), extending for many miles above Telegraph Creek, consists of a series of narrow gorges, averaging about 300 feet deep, cut in the bottom of a great, broad valley. Most of the gorges are cut in lava flows, but in places canyons are cut in the older rocks, the lava having filled the old channel and forced the stream to cut a new one alongside. An old channel that is filled with glacial drift down to the water's edge occurs on the southeast side about 3 miles above Telegraph Creek (Plate III B). This shows that a channel nearly as low as the present one existed prior to the deposition of the latest glacial drift. There are in places several lava flows, the lowest of which fill channels cut in the older rocks, as on the south bank opposite the mouth of the Tahltan (Plate III A); the upper flows occasionally fill channels cut in the lower flows. River gravels occur in places beneath the lowest flow, as opposite the mouth of the Tahltan, and at other places between the flows. The lowest channel in the vicinity of the mouth of the Tahltan is about 40 feet above the present stream. Other channels, containing gravels beneath lava flows, occur at considerably higher levels on both sides of the Tahltan near the trail crossing, along the trail about 1 mile below the mouth of the Tahltan and in the vicinity of Telegraph Creek. The gravels in these higher lava-buried channels were probably derived from glacial drift, for they contain many boulders of granitic rocks, up to 1 foot in diameter, which are foreign to the locality and must have been derived from a considerable distance. The gravels are well water-worn and are slightly cemented in places near the outcrop, but in other places are uncemented and have much the same general appearance as the undoubted glacial gravels of the area. It is probable, therefore, that some of the later if not all the lava flows are Pleistocene in age. The youthful character of the canyon of the Stikine

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[1]Geol. Surv., Canada, Pub. No. 629, pp. 67-70.
[2]Op. cit., p. 70.

also seems to show that it is Pleistocene and Recent in age rather than late Tertiary. The gravels in the lowest channels, however, are different in character from those in the higher channels, in that they are finer, are more weathered, and are more cemented. It may be, therefore, that some of the lower flows are late Tertiary in age.

Placer gold is known to occur in the lava-buried gravels near the mouth of the Tahltan, but whether in sufficient quantities to pay for mining is not known. It is to be expected that the richest deposits occur in the lowest channels, where the gravels rest on the old bedrock, but these gravels appear to be cemented. It may be, however, that they are cemented only near the outcrop. A discouraging feature is that, although the old channels have been cut away for considerable stretches by the present streams, only a little coarse gold is reported to have been found on the bars or in the beds of the present streams. Some prospecting of the old channels has been done, but the question whether they contain workable deposits of placer gold does not appear to have been definitely determined.

Gravels overlain by volcanic tuffs occur in Dease Lake area, in the bed of a small creek flowing into Little Eagle river from the east. The creek heads near a sharp peak (a cinder cone) about 1 mile east of the valley and is the third creek below Goldpan creek. In the upper part of the creek valley, northeast of the mountain, are exposures of well-consolidated tuffs that contain numerous glaciated boulders of granitic rocks. Erratics occur on the sides and summit of the cinder cone. It is elongated in the direction of glacial ice movement and was evidently eroded to some extent by the ice. The volcanic eruption occurred before the advance of the last ice-sheet, but the glaciated boulders in the tuffs show that glaciers existed in the area during or before the time of eruption. The cinder cone, therefore, is probably early Pleistocene in age. The gravels beneath tuffs in the bed of the creek directly north of the cone are only slightly cemented and appear to be glacial gravels. It is not known whether they contain any placer gold.

Sandstone and conglomerate overlain by volcanic tuffs and lava flows occur in the bottom of the deep mountain valley just east of the mountain at the head of Goldpan creek. A large cinder cone, considerably eroded, occurs at the head of the valley. The valley for a mile or more downstream at one time was filled with tuffs and lava flows, but has been partly re-excavated by stream and ice erosion. No gravels were seen beneath the tuffs in the valley, though they may occur. Glacial gravels occur in places along the sides of the valley and are buried beneath cinders that have slidden down from the steep slopes above. These gravels are not likely to contain much placer gold and should not be confused with the gravels that in other places underlie the lavas and tuffs.

Gravels overlain by lavas occur, as already pointed out (page 55), in Eagle River valley above the junction of Little Eagle river. They probably occur at numerous other places in this general region. The lava and (or) tuff-buried gravels of the Eagle River country are not definitely known to be gold-bearing. They probably have not been prospected to any great extent and appear to be worthy of investigation as a source of placer gold.

FUTURE POSSIBILITIES

A factor which has discouraged prospecting and mining development in Cassiar is the high cost of transporting machinery and supplies into the region. The freight rate in 1925 from Wrangell to Telegraph Creek was 2½ cents a pound and from Telegraph Creek to Dease lake 8 cents a pound. Some of the mining companies, however, were able to reduce these costs somewhat by using their own means of transport over the trail. It is probable that the freight rate over the trail will be considerably reduced when the road is sufficiently improved to permit of motor traffic, as is expected will be the case in the autumn of 1926. It is obvious, however, that the cost of transportation is bound to remain fairly high and that the freight rate from the coast to Dease lake cannot be reduced much below $150 a ton. Another factor which must be taken into consideration by prospective mining companies is the short length of the working season, which in practice is limited by the arrival of the first boat on the Stikine in the latter part of May and the departure of the last boat about October 1. But mining work can be done during a longer period if the men remain in the district during the winter.

The general possibilities for placer mining in the region have been outlined in the body of this report and include hydraulicking on Dease, Thibert, Deloire, and Mosquito creeks, dredging on Little Eagle river, and individual mining on Goldpan creek and at other places. The lava-buried placers of the Stikine and somewhat similar deposits in the Eagle River country, although they are not known to contain pay-streaks of any great value, appear to be worthy of further prospecting. There is a vast region northeast and east of Dease lake, drained by Turnagain and Kechika rivers, in which a great deal of prospecting has been done with no very important results, but it is very improbable that all the streams in this region have been prospected and the discovery of Goldpan creek showed that, although some prospecting had been done on the creek, the pay-streak had been missed. In connexion with further prospecting in Cassiar, there are certain points brought out by Dawson and McConnell's work and by the work of F. A. Kerr and the present writer, that may be of some value to prospectors. In order that placer gold may occur in any region it is necessary that gold-bearing veins occur in places in the bedrock. Rich placer deposits do not necessarily indicate that rich lode deposits occur in the vicinity, for the placer gold may be the concentrates from the wearing away of a great thickness of the country rock that contained only small gold-bearing veins. On the other hand, rich lode deposits may occur and there may be no placer deposits because of the effects of glaciation or from some other cause. Cassiar region, as well as Cariboo district in central British Columbia, was heavily glaciated and conditions in it, regarding the occurrence of placer gold, therefore, are quite different from those existing in the Klondike region which was not glaciated. Most of the placer gold was released from the bedrock and concentrated into pay-streaks in the valley bottoms before the glaciers of the Pleistocene period came into existence. The glaciers partly destroyed the old pay-streaks and scattered the gold. In valleys that were protected from ice erosion parts of the old pay-streaks were preserved, but the gold, for the most part, has been reconcentrated by stream erosion of the glacial drift and of the valley bottoms.

Dease and Thibert creeks were the main gold-producing creeks of the region because parts of the old channels of the creeks were preserved in the form of drift-covered rock benches along the sides of the present stream valleys. Creeks that are similar in character to these creeks, therefore, should be searched for by prospectors. The region drained by Turnagain and Kechika rivers is said by prospectors who have been through parts of it to be mountainous throughout, except that the lower parts of the rivers and of their main tributaries have very broad, drift-filled valleys. It is improbable that many valleys similar in character to Dease and Thibert creeks occur in this region, but there may be a few. They are most likely to occur in places where the trend of the valleys is nearly at right angles to the direction of movement of the ice-sheet, and where the valleys do not head in glacial cirques. Valleys that have the rounded U-shape of glacially eroded valleys should be avoided. In narrow, youthful appearing valleys such as Goldpan creek, placer gold, if it occurs, is likely to be most abundant in the bed of the stream in places where the surface gravels extend down to bedrock. If boulder clay occurs beneath the surface gravels in the bottom of the valley there may be some concentration of gold on the surface of the clay, but there is likely to be little beneath the clay. Narrow and deep V-shaped valleys, with moderate gradients, even if they do not have rich benches of the old channel along the sides, are more favourable than wide valleys. If boulder clay occurs in the bottom of these, there is a possibility that a pay-streak lies beneath the clay. The Recent rock canyons, which are usually easily recognized by their nearly vertical sides and youthful appearance, are unfavourable for the occurrence of placer gold, unless they happen to have been cut down directly below the old channel of the stream. Many of them indicate that a buried channel, in which placer gold is more likely to be found, occurs alongside the new channel.

Most of the placer gold in Dease Lake area is coarse and is evidently local in origin. The streams that traverse the granitic rocks forming a considerable part of the Cassiar range have not been found to contain paying deposits of placer gold, whereas some of the streams traversing the adjacent rocks do. It would appear, therefore, that creeks flowing through regions bordering the intrusive granitic masses are the most favourable for future prospecting for placer gold. If the bedrock in the vicinity of a creek basin is mineralized even to a slight extent it is possible that placer deposits occur in the creek bottom, providing other conditions are favourable. If the bedrock, as in parts at least of the granitic areas and in other areas, shows no signs of mineralization it is improbable that placer deposits occur.

There is a long-standing rule among placer miners of Cariboo and elsewhere that streams like the lower Liard, where only very fine gold was found on the bars, are "no good." This opinion is based on the fact that such gold is "flood" gold and has been transported long distances. It is concentrated in a thin pay-streak near the surface of the bars and, unless some fairly coarse gold occurs along with it, there is little chance of paying deposits occurring on the bedrock beneath the bars or on the benches. Such deposits occur most abundantly along the large streams in a gold-bearing region. They are easily found and the workable deposits in Cassiar, few of which existed, probably have been mined out. The presence of flood or bar gold along a stream in this region does not necessarily indicate that richer deposits of placer gold, from which the flood gold was derived, occur father upstream, for the gold may have been derived by stream erosion of the glacial drift. The glacial drift was transported, possibly for considerable distances, so that the original source of the gold may be downstream from the locality where it occurs on the bars. The gold in the drift was transported, from its original source, in the direction in which the glaciers moved. Only fine gold, however, appears to have been thus transported, along with the glacial drift, for any great distances. Much of the gold in the glacial gravels is fairly coarse and uniform in size, as if sorting and transportation by powerful streams had taken place, but it has not been carried far from the original source. The coarse, nuggety gold, in places where the old pay-streaks were eroded by the ice or by powerful streams issuing from the ice, tended to sink down through the gravels and to remain in the valley bottom not far from its original source. It was transported for short distances downstream and was scattered. This applies to those valleys that were only slightly eroded by the ice. Placer gold, as a rule, does not occur in the bottoms of glacial cirques nor in the bottoms of heavily glaciated valleys. It does not occur in paying quantities in the moraines nor in the glacial drift outside the present or the old valleys. A pay-streak may occur on the true or on a false bedrock beneath glacial gravels in a valley bottom, for if the gravels are water-saturated and are porous, any gold in them will tend to settle to the bedrock. This illustrates why, as every good placer miner knows, it is necessary to reach the bedrock to determine whether or not a stream is gold-bearing. There are, however, as stated above, certain considerations which may indicate to the prospector whether a stream is worth testing at depth.

The question whether really important placer fields remain to be discovered in Cassiar is difficult to determine, for it is impossible to tell from the records how many of the creeks have been prospected and how thoroughly the work was done in those creeks that were tested. It is fairly certain that most of the creeks have been tested in places where the ground is shallow and that the deep ground has been tested on very few of the creeks. In this connexion it should be noted, however, that rich gold-bearing creeks, even in glaciated regions like the Cariboo, rarely failed to give at the surface some indication of their buried wealth. Nevertheless, important discoveries, for example Cedar creek, were made in Cariboo after sixty years of prospecting had been done, and it is possible that new finds will be made in Cassiar, for, as in Cariboo, the placers are in many places buried beneath glacial drift and, therefore, are difficult to discover.

DEASE LAKE AREA, CASSIAR DISTRICT, B.C.

By F. A. Kerr

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INTRODUCTION

A large demand for maps of Dease Lake area in northern British Columbia and for information regarding the geology was created by the discovery in the autumn of 1924 of placer gold on Goldpan creek, a tributary of Little Eagle river. A rapid reconnaissance survey along the regular route of travel through the district was made by G. M. Dawson[1] in 1887, but the results of this were not entirely available to the public, as the maps accompanying his report were out of print and very little information could be procured from other sources. The work represented by the present report and its accompanying map was undertaken, therefore, to meet the needs of the situation.

Cassiar district, in which Dease Lake area is situated, is an old placer mining field which has gradually declined in production. Since the early discoveries much prospecting for both lode and placer deposits has been done with no very important results, but it was known from Dawson's work that geological conditions appeared to be favourable for the occurrence of mineral deposits. In order to determine the possibilities of the district for further prospecting and mining and to furnish a geological and topographical map for guidance in prospecting, an area in the vicinity of Dease lake was mapped. The bedrock geology was examined by the writer and the placer deposits were investigated by W. A. Johnston, whose report appears elsewhere in this volume.

The map accompanying this report (No. 2104) represents the new surveys made in 1925, except that the latitude and longitude of Lake House as calculated by Dawson were again used, and that G. M. Dawson's original

[1] "Report on an Exploration in the Yukon District, N.W.T., and Adjacent Northern Portion of British Columbia"; Geol. Surv., Canada, Ann. Rept., vol. III, pt. I (1887), and Publication 629 (1898).

survey of 1887 of Dease river from Cottonwood to Eagle river was adopted. The altitude of Dease lake, 2,440 feet above sea-level, was established by the British Columbia Government road survey of 1925 by levelling from Telegraph Creek where the altitude was determined by readings of several aneroids.

R. L. Junkin and Leonard Greer rendered assistance in the field. G. W. H. Norman is mainly responsible for the geological, and W. A. Johnston for the topographical, mapping in the Eagle River country in the eastern part of the area. The officials of the Hudson's Bay Company and of the Barrington Transportation Company, and Frank Callbreath, aided the progress of the work materially by rapid and efficient transportation of supplies, equipment, and the personnel of the party. The writer is indebted also to W. Scott Simpson, Indian Agent, for assistance in various ways.

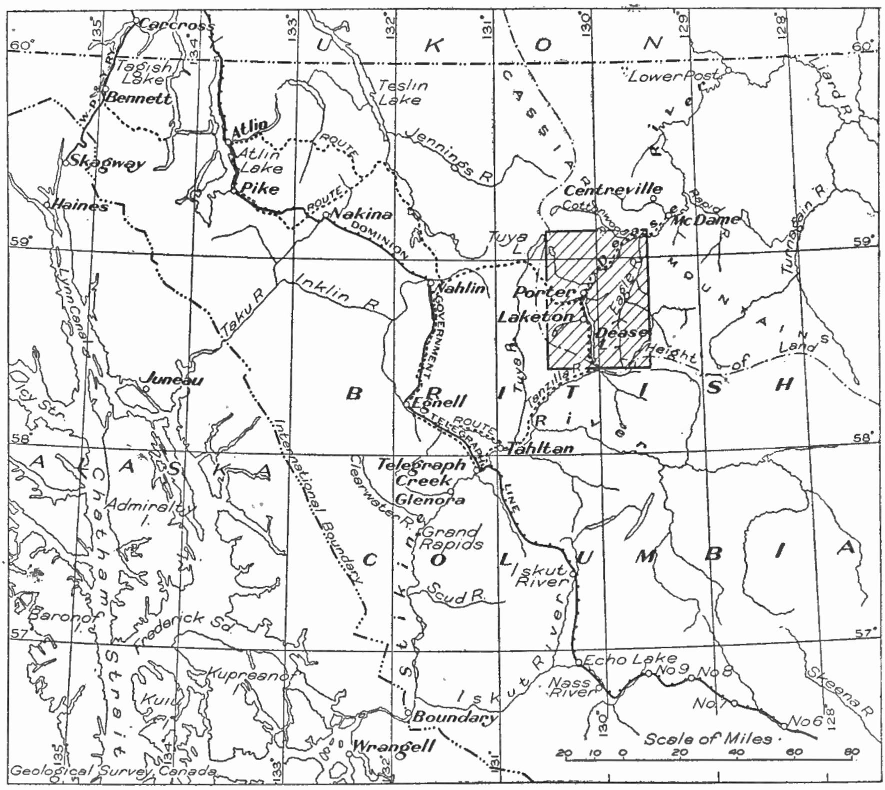

FIGURE 8. Index map showing location of Dease Lake area, Cassiar district, B.C.

LOCATION AND AREA

Dease Lake map-area is located in Liard mining district, in northern British Columbia (Figure 8). It forms part of what is commonly known as Cassiar district. Its northern limit is 60 miles south of the Yukon-British Columbia boundary and 110 miles east of the Alaska-British

Columbia boundary. The area includes about 2,000 square miles and lies between latitudes 58° 10′ and 59° 30′ and longitudes 129° 20′ and 130° 40′. It is partly on the Arctic-Pacific divide. The majority of the streams within the area are tributary to Dease river, which in turn is tributary to the Liard and the Mackenzie. A few of the streams in the western part flow west to the Tuya and some in the southern part flow south to the Tanzilla. Both of these rivers are tributaries of the Stikine which reaches the Pacific by a westerly course through the Coast range.

The main routes of travel between the western and eastern parts of northern British Columbia pass through the map-area. Dease lake and Dease river form two links in a chain of thoroughfares which constitute the main highway. The system is completed to the west by a 73½-mile road to Telegraph Creek and Stikine river, and to the east by the Liard and its tributaries.

BIBLIOGRAPHY

A complete bibliography is given on page 34 by W. A. Johnston in his report on the placer deposits. His report also includes a description of climatic conditions and a history of mining and prospecting in the area. Previous work has been confined almost entirely to investigations of the placer deposits.

TOPOGRAPHY

Dease Lake area includes parts of two distinct physiographic provinces, the Cassiar range which trends northwest-southeast and occupies the northeastern part of the area, and a dissected plateau above which isolated mountains rise. A third province, which, however, is poorly defined, includes the Ho Tai Luk or Tanzilla Butte range which trends north and south. It may be regarded as forming part of the plateau province. Its northern extension just enters the southeast part of the area. The boundary between the two main physiographic provinces is clearly marked by a series of valleys which are successively occupied from northwest to southeast, by Bull creek, part of Canyon creek, Beady creek, and Little Eagle river. To the northwest a similar well-defined boundary can be seen to continue for miles. Four miles beyond the area the bounding valley is occupied by the northern part of Tuya lake.

The Cassiar range is reported to extend southeasterly as far as the headwaters of Finlay river and to continue north for 80 miles or more. It has a general northwest-southeast trend. The part included in Dease Lake area constitutes the southwestern edge of a great mountainous area. The highest peaks rise to an elevation of over 7,000 feet, which gives a total relief of more than 4,500 feet. The range is made up of sharp peaks and rugged, saw-tooth ridges averaging over 6,000 feet in height. They present no definite orientation, and are bounded by pronounced valleys which have irregular trends. The valleys as a rule are short and have quite steep gradients. Within the map-area two great valleys dissect the range, namely, Eagle River and Dease River valleys. Both of these rivers flow north. Their valleys have low gradients and are wide, that of Dease river being notably so. A third valley which is even wider though not so deep is occupied by a tributary of Canyon creek. Unlike the other two this valley drains south.

The physiographic province to which the rest of the area belongs extends far to the west and southwest. Parts are so distinctly plateau-like as to have acquired names such as "Level mountain", but within the map-area the plateau aspect is somewhat obscured because a number of prominent peaks and groups of peaks rise above the general elevation and because valleys cut deeply into it. The greater part of the plateau in the map-area is relatively flat with an elevation of between 3,000 and 4,000 feet. Some of the prominences rising above the plateau-level have elevations of over 6,000 feet. They have no definite arrangement. In the northwestern and southwestern parts of the map-area they constitute small ranges and give to these sections a much more rugged aspect. The plateau area is cut by three deep valleys, that of Dease lake with a north-south trend and those of Dease and Thibert creeks with east-west trends. There are many smaller deep valleys, most of which have east-west trends. The area is also divided into parallel strips by several large, open, north-south valleys of which those of Little Eagle river and Berry-Killarney creeks are the most important.

Dease Lake valley is the outstanding feature in the area. The greatest depth of the lake, as measured, southeast of the abrupt slope near Steamboat point, was 382 feet[1]. Towards Porter Landing the lake shallows rapidly and north of this point is only a few feet deep. Between the deepest spot and the mouth of Dease creek the depth ranges irregularly between 360 and 180 feet. Off Dease creek the lake is shallow, averaging about 100 feet. From Laketon to Gull Rock it is in most places over 300 feet deep, but in some is less than 200 feet. In the constricted part near Ninemile point and Gull Rock it averages about 250 feet. From Gull Rock to Lake House the lake gradually shallows to a depth of 50 feet close to the wharf where there is a fairly steeply sloping beach.

GENERAL GEOLOGY

Though this chapter is a description of the bedrock geology of the whole area it is based mainly on work done in the western part. Examples are taken from this section of the area and its features described more fully, merely because of greater familiarity with them than with those in the east. However, it is thought that the two parts of the area are so much alike that in a general way the descriptions are equally applicable to both.

In the Cassiar range, above timber-line, which is about 4,700 feet, exposures of rock are numerous and the higher peaks are mainly bare rock. Below timber-line, owing to the abrupt slopes, outcrops are fairly abundant and many streams in their rapid descents cut through to bed-rock. Along Dease river, on the other hand, exposures are rare.

In the plateau province there are large tracts with little relief. These are heavily wooded or once were, but have been burnt over and are now a tangled mass of fallen trees and "buck brush". Some are covered by lakes and swamps. The large north-south valleys are largely filled with drift and are partly occupied by swamps and lakes. Only on the high peaks and ridges and in the great east-west valleys, such as those of Dease and Thibert creeks, are good rock exposures found. These, owing to

[1]Depths given were taken approximately in the middle of the lake except where otherwise stated.

the great distances which separate them and because of the intricate nature of the structure, did not offer a good opportunity for study of the geology. It was not until French mountains were traversed that exposures were found adequate to give some definite clue to the problems involved. Once this was gained it was possible to interpret what was observed elsewhere.

The rocks are folded into a large number of small, irregular folds which apparently have no definite arrangement, shape, or trend, and whose lateral extent is as variable. There are also several angular unconformities which still further complicate the structure.

Though limestone is abundant—confusingly so, for similar limestones occur at several distinctly different horizons—fossils are extremely rare. Five collections were made: three in French mountains from what is fairly definitely the same horizon; one on mount Sullivan, and the fifth from the head of Dease lake. The stratigraphic succession was not entirely clear until the fossils had shown one limestone to be Permian and another to be Triassic.

The Palæozoic (Dease series) is represented by a great thickness of well-bedded sediments of various sorts, topped by a massive limestone formation. This limestone is of Permian age; the rest of the series probably represents a considerable time interval which may include several geological periods.

The Mesozoic rocks of the area are subdivided into the Thibert series, the McLeod series, the Cassiar batholith, and the Beady formation. The Thibert series overlies the Dease series and is separated from it by an angular unconformity. Beds of serpentine which are altered basic lavas and tuffs constitute the base of the series. The serpentine is overlain by, and interbedded with, limestone and dolomite, the upper part of which as determined from one poor collection of fossils is Upper Triassic in age. The McLeod series, probably of Jurassic age, overlies the Thibert series and is separated from it by an angular unconformity. It is a thick series of volcanics—breccias, tuffs, and lavas—interstratified with argillites, quartzites, and slates.

All these formations are intensely folded and are cut by the great Cassiar batholith—an igneous mass of very complex composition. The exposed part is thought to be of early Cretaceous age. Boulders from it form part of the Beady formation—a conglomerate mass of small extent, slightly deformed and probably of late Cretaceous age. The rocks of the area are cut in many places by basaltic dykes of late Tertiary and (or) early Pleistocene age. Several large and small volcanic cones and small areas of lava constitute the extrusive phases of this igneous activity.

Table of Formations

Recent	Alluvium	
Pleistocene	Glacial drift	
Erosional unconformity		
Late Tertiary and in part (?) early Quaternary	Tuya formation	Basalt, tuffs, breccias, sandstone, and conglomerate

Angular unconformity

Upper Cretaceous?............	Beady formation............	Conglomerate

Erosional unconformity

Lower Cretaceous?............	Cassiar batholith............	Granite, granodiorite, diorite, gabbro. Part may be Upper Jurassic

Angular unconformity

Jurassic?......................	McLeod series...............	Conglomerates, basalt, tuffs, breccias. Argillite, quartzite, and slate

Angular unconformity

Triassic......................	Thibert series...............	Conglomerate, serpentine, and limestone

Angular unconformity

Permian to Ordovician?.......	Dease series..................	Limestone, slate, schists, and quartzite

DEASE SERIES

The Dease series includes all the Palæozoic rocks of the area. Though these are of considerable thickness it was not found feasible to subdivide them. In some parts of the area a thick limestone member at the top of the series can be fairly readily distinguished from the rest, otherwise there was found no basis upon which a subdivision could be made.

All the rocks along Dease lake and the upper part of Dease river were referred by G. M. Dawson [1] to the Palæozoic. It is now known that some of the rocks are Mesozoic.

The Dease series is by far the most extensive in the southern part of the map-area. It probably underlies at no very great depth practically the whole of the area south of the batholith. The younger formations occur mainly as isolated masses upon it. The greater part of the low-lying areas south of the batholith are underlain by the Dease series. Dease lake, Dease creek, Eagle river, and most of the other large streams in the southern part of the area, occupy valleys which lie almost entirely in rocks of the Dease series. Where these rocks occur at unusual heights it is generally apparent that younger formations have comparatively recently been removed. Mount Sullivan, Johnsons Knolls, French mountains, Vowel mountain, and others, though made up mainly of the Dease series rocks, are capped to some extent by the more resistant material of the McLeod series. Their bases of Palæozoic rocks have gentle slopes which in many cases become abruptly steep above the contact. In the Cassiar

[1] Geol. Surv., Canada, Ann. Rept., vol. III, pt. I (1887) and Pub. 629 (1898).

range areas of the Dease series are marked by comparatively low, well-rounded hills which are in marked contrast with the rugged peaks formed of the batholithic rocks and the McLeod strata.

The Palæozoic rocks consist of a great series of conformable sediments of various kinds. As previously stated the top member of massive limestone can in most places be fairly readily distinguished from the rest of the series. It is pink and brown in places, but mainly light grey. It is mostly crystalline and shows signs of metamorphism. As a rule it is fairly pure, though some of it in French mountains contains much brown sand. It is rarely well bedded, but there is generally some semblance of indefinite bedding. Fossils are extremely rare and where found are very poorly preserved. Laterally the limestone varies only slightly.

As the erosion which developed the unconformity at the end of the Palæozoic removed much of the limestone it is very doubtful whether the total thickness is present anywhere. At the points where it seems to be thickest it is not possible to determine the top and bottom of the formation, and as the limestone is mainly massive and the structure complicated and obscure, its thickness cannot be accurately estimated. In French mountains at one point it constitutes a hill several hundred feet high, which gives the impression that the thickness is several hundred feet. It is probably between 200 and 500 feet. The limestone, however, even within French mountains, in many places is thin or is entirely absent below the younger formations. In the greater part of the map-area these younger formations are found resting directly on older rock.

The age of the top, massive limestone member is quite definitely fixed as Permian by several collections of fossils. Of these E. M. Kindle writes:

"Lot 1. French mountains, Cassiar district, B.C.

"Some of the specimens show small garnets; the notable degree of metamorphism which these indicate is probably responsible for the poor state of preservation of most of the fossils present. These may be listed as follows:

Fusulina sp. indet.
Crinoid stems and base of one calyx
Amblysiphonella? sp.
Bryozoa (fragments)
Productus sp.
Leptodus cf. *tenuis*
Spirifer cf. *cameratus*
Eumetria? sp.
Athyris sp.
Spirigerella?

"This lot is of unusual interest, in spite of the fragmentary condition of most of the species represented, because of the presence of the curious brachiopod which is here listed as *Leptodus* cf. *tenuis*. This genus has long been known in China and India under the generic name *Lyttonia*. More recently it has been recorded from the Guadaloupian fauna of Texas. The Texan occurrence is the only one recorded for North America so far as known to the writer. This genus (under the name *Lyttonia*) is a characteristic element of the 'Middle Productus limestone' of India. Another unusual fossil in this fauna, which I have provisionally referred to the calcareous sponge *Amblysiphonella*, is unknown in the interior faunas of this continent. This fauna is considered to be of Permian age.

"Lot 2. French mountains, Cassiar district, B.C.

"The collection consists largely of fragmentary specimens in a light grey limestone, many of which appear to be representatives of the calcareous sponges. The fossils referred to the Calcispongiæ are provisionally listed as follows:

Amblysiphonella sp.
Margaritina? sp.
Steimmannia sp.

"A large pelecypod of unusual type is present, but in too fragmentary a condition for even generic determination. The collection also includes a Bellerophon-like shell.

"This fauna, like that in lot 1, is more comparable with the Salt Range fauna of India than with anything else known to me. It is considered to represent the same general horizon as 1.

"Lot 3. French mountains, Cassiar district, B.C.

"This lot contains a species of calcareous sponge identical with one of the forms in lot 2 and represents apparently the same general horizon as lot 2.

"Lot 4. Mount Sullivan, Cassiar district, B.C.

"Contains certain vague, indefinite-looking forms which probably belong to the calcareous sponges. There is nothing in the character of the material to suggest an horizon different from 2 and 3, but definite evidence as to the horizon represented is lacking."

This limestone probably correlates with that which occurs east of McDame creek, a tributary of Dease river 12 miles below the Eagle, of which Dawson writes,[1] "The range to the east of McDame creek is largely composed of limestone which, striking in a northwest and southeast direction, constitutes also the mountains on the south side of the Dease. The dip is generally westward, at varying angles, and the limestones are associated with reddish shales, and near the mouth of Rapid river were observed to be interbedded with dolomitic layers and calcareous schists. The total thickness of the strata brought to the surface along this part of the river must be very considerable . . . . . . Limestones near the western or upper part of the river section contain numerous obscure fossils, including brachiopods, corals, and apparently a sponge-like organism. I also satisfied myself of the occurrence of *Fusulina*, on weathered surfaces, proving the Carboniferous age of the rocks in question. The pure limestones are usually grey and are not highly crystalline."

Below the Permian limestone lies a great thickness of sediments. Though variable, these show the same general aspect throughout, except that in the higher beds the calcareous content is pronounced, whereas in the lower it is insignificant, and that parts are made up entirely of black slate, which is rather uncommon. Throughout the lower part of the series the quartz content is high, so that a very large percentage of the rock may be classified as quartzite, quartzitic slate, or quartzitic argillite. True slates with a well-developed cleavage are rare except in a few localities. No conglomerates or coarse-grained rocks of any sort were found. The rocks are generally thinly bedded. Rarely do the beds exceed one foot in thick-

[1]Op. cit.

ness and in only a few cases is massive material found. This is in direct contrast with some of the younger formations and is a decided aid in making differentiations.

Quartzites are common. They are dominantly cherty grey—in fact many of them appear to be cherts. Others show hard kernels of chert in a somewhat softer groundmass. These are most abundant in the lower part of the series. There are other compact, grey and green quartzites with a less dense texture, which as a rule have a small argillaceous content. A few of these occur in fairly thick beds and resemble somewhat the rocks of the McLeod series. Many of the quartzites are granular—a texture which seems to be largely the result of recrystallization or cataclasm of the quartz. In some, however, it is the original texture. On Beady creek and elsewhere there are "tapioca quartzites"—grey, somewhat granular rocks with kernels of white, clastic quartz which are about the size of tapioca grains and a little larger. Pure quartzites are rare. The cherty beds, however, probably have a very high siliceous content.

The argillaceous rocks are mainly argillites, for few show well-developed slaty cleavage. They too are dominantly grey, fairly light. They are dense and hard in general aspect and greatly resemble some of the quartzites. Slates are found in minor quantities throughout the series. They tend to be somewhat darker than the quartzites and argillites. In the area including Red Ledge, Vowel, and Defot mountains slates are abundant. These are of a great variety of colours: red, green, brown, black, and grey. They are finely laminated, hard, and brittle. As a rule all the slates show evidence of much metamorphism, but in some places they are hardly more than shales. A few are calcareous.

Fairly thick deposits of black slate occur in several localities, notably south of Anvil mountain, on Red Ledge mountain, and east and northwest of Lake House. The position of these in the series is not clear, but some of them seem to represent the base of the exposed Palæozoic. Graptolitic black shales of Ordovician age associated with other rocks similar to those in Dease Lake area were found by Dawson on the lower Dease[1]. There is a suggestion in this lithologic similarity that some of the rocks of the Dease series may be of Ordovician age. Otherwise there is no clue to the age of any of the rocks below the Permian limestone.

Limestone beds are common in the upper part of the series below the massive Permian limestone. On Dease creek and its tributaries they range in thickness from a few inches to 20 feet. The upper beds show no pronounced differences from the massive Permian limestone, but lower down they are a darker grey and appear to be more highly crystalline. Associated with these are brown and grey dolomitic beds. Some of the limestones are arenaceous or argillaceous and many of the other rocks with which these are interbedded are quite calcareous. Thus, due to its calcareous content, the upper part of the series presents an appearance somewhat different from that of the lower part. This, however, is by no means definite enough to make it possible to assign isolated outcrops either to the upper or lower part.

Schists are rare in the series. They are intermediate in composition between the main types of rock already described. Some of the rocks with chert nodules are true schists. By far the greater part of the rocks

[1]Op. cit., p. 93.

of the series are intermediate phases. In the upper part they may best be designated as calcareous argillites, slates, and quartzites, whereas in the lower part they are quartzitic argillites and slates, and quartzites.

The nature of the structure makes it impossible to estimate the thickness of the exposed Palæozoic formations. A section up Bucks gulch shows over 4,000 feet of the calcareous beds below the massive Permian limestone. This probably represents nearly the total of these beds. The relief and structure suggest that there must be at least 10,000 feet of strata in the series.

The age of the upper massive limestone, as already stated, is Permian and the age of the black slate possibly Ordovician. Beyond this nothing is known. No unconformities in the series were observed and no marked change in the character of the sediments. The series seems to be the result of continuous deposition and probably represents a large part of the Palæozoic. The character of the sediments gives no clue to their age.

THIBERT SERIES

Rocks of the Thibert series are found in a few, isolated, widely separated masses. These as a rule are small except in the southeastern part of the map-area, where two are of considerable extent. Along the southwestern edge of the batholith and the southern edge of the map-area the rocks of the series are more nearly continuous than in other parts of the area.

The lower parts of the series are serpentine rocks which as a rule are easily eroded. As a consequence valleys commonly occur in them. The present and pre-Pleistocene valleys of Thibert creek, for a few miles above and below Berry creek, are largely in this material. At the eastern limit of the mass in the eastern part of the area, however, there is a high mountain made up largely of green serpentine. The upper limestone members are somewhat more resistant. They constitute part of the hill west of Lake House, part of the serpentine mountain just described, and other hills of lesser prominence.

The Thibert series is made up mainly of two entirely different types of rock—serpentine and limestone. These can be readily separated in the field, but owing to the limited extent of the areas, in places of serpentine and in others of limestone, it was not feasible to map them separately.

A conglomerate made up of materials derived from the Dease series is found in a very few localities at the base of the series. Nearly everywhere, however, the serpentine is in direct contact with the lower rocks. It is altered lava which, judging from the character of its base and the associated rock—limestone—was extruded on the sea bottom. The serpentine is mainly the common, greasy green, much slickensided variety. It is fairly uniform in character. Under the microscope it is observed to be almost entirely serpentine with some pyrite and magnetite. Nothing of the original lithologic character of the rock, other than that it was very basic, as indicated by the serpentine content, could be ascertained. In places the rock contains hard, dark grey, or black kernels which under the microscope are found to be mainly serpentine with much magnetite and pyrite. It is cut by light green veins of fibrous serpentine and small veins of asbestos.

The limestone is well exposed in the mass west of Lake House. Directly overlying the serpentine is a rock which in general appearance is like a limestone. It weathers to a very rusty brown and for this reason is very striking. In places the colour persists within the rock, but commonly it is merely a surface coating. The rock near the contact contains many silver-like masses of green serpentine. It ranges from green to white, grey, brown, and even brick red. It is exceptionally hard for a rock of this type and is partly dense and partly crystalline. It is well bedded and is clearly sedimentary. Much of the rock reacts only slightly to acid and some not at all. Under the microscope it is seen to be almost entirely carbonate with some serpentine. Some of the carbonate is calcite, but probably much is either dolomite or magnesite. The rock grades upward into a massive, crystalline, grey limestone which is very similar to the limestone of Permian age.

Another good section was seen on Thibert creek where rusty carbonate rock is interbedded with the serpentine. The section shows at the base a fairly thick serpentine bed which is overlain by a thin, rusty bed, followed by a thin, serpentine bed, and above by a considerable thickness of rusty rock which grades upward into limestone. The lower parts of the carbonate beds contain small and large masses of serpentine which are strongly suggestive of altered volcanic bombs, cinders, and ash. There is a considerable variety of materials. Some are lemon yellow with serpentinous-earthy to crystalline textures. These are probably carbonate tuffs with varying quantities of the two main constituents. At the mouth of Flat creek in the northwestern part of the area the four members were again observed, but all are thin and there is much less of the definitely tuffaceous material.

The serpentine apparently represents altered lavas and tuffs. They were undoubtedly very basic, probably olivine basalts, and tuffs of a similar mineralogical composition. The rusty brown rock probably represents altered calcareous tuffs and limestone. The alteration was probably simultaneous with and a result of the serpentinization of the lavas. Magnesium and iron were derived from these and from the included volcanic ash and cinders. Calcite was altered to dolomite, magnesite, and possibly siderite. The resultant rock is exceptionally hard and owing to the iron content becomes rusty brown on weathering. The contact between the serpentine and the rusty brown rock looks very much like an intrusive contact, the serpentine appearing to represent an intrusive which had greatly altered and mineralized the limestone. The alteration, however, was probably effected long after the igneous activity which produced the lavas. In many places the rusty outcrops have been staked as mineral claims probably because of the rustiness.

The Thibert series definitely overlies the Permian limestone unconformably. One collection of fossils from the limestone of the Thibert series was made at a locality 1 mile south and $\frac{3}{4}$ mile west of the head of Dease lake. Of these, Professor H. W. Shimer writes:

"The few fossils were very poorly preserved. But one specimen showing transverse sections of six corallites is without very much doubt *Isastrea vancouverensis* characteristic of the Upper Triassic Coral Reef Fauna of western North America. Another compound coral has thick walls characteristic of *Isastrea cowichanensis*, but with a diameter of only a millimetre instead of a normal 3 millimetres. It is hence not this species. A third coral may be a *Calamophyllia*."

The age of the limestone is thus fairly definitely fixed as Upper Triassic. Probably the altered volcanic rocks immediately below it are not much older than the limestone and these also may be included in the Upper Triassic.

At the mouth of Flat creek the lower serpentine bed probably does not exceed 10 feet in thickness and the upper 20 feet. The lower limestone is about 6 feet thick and the upper 20. The upper limestone has probably been largely removed by post-Thibert erosion. Toward the east as far as Red Ledge mountain the serpentine is thin and the limestone is largely cut off by erosion. Beyond this the altered lavas thicken slightly, until at Deloire creek they are several hundred feet thick, but on Porter Landing mountain they are again somewhat thinner. At the head of Dease lake they are thin, but the limestone which is well exposed is several hundred feet thick. In the eastern part of the area both the serpentine and limestone have considerable thickness, for they constitute quite high mountains.

The serpentine unconformably overlies the Dease series. Though at many places it has been removed by post-Thibert erosion it is unlikely that it was ever continuous. In fact it is remarkable that it was even as extensive as its present distribution indicates, for in the area adjacent to Dease lake it is generally thin. The lavas must have been very mobile to have spread out over such a great area in so thin a sheet and the land surface must have had very little relief. Many places where the serpentine is absent probably represent the higher parts at that time, which were not covered by lava. The clean contact at the base of the serpentine strongly suggests that the surface on which the lavas were deposited was submerged. At any rate the presence of limestone in the upper part of the series clearly shows that submergence prevailed toward the end of the period of volcanic activity and later.

No dykes nor other intrusives which might be assigned to this period were observed, though it is possible that some of the masses included in the McLeod series, as part of Porter Landing mountain, may be intrusive phases of the serpentine-producing rocks. The variations in thickness suggest that the source of material was to the east or northeast and may have been in the area now occupied by the Cassiar batholith.

MCLEOD SERIES

The McLeod series, which is made up of lavas, breccias, tuffs, argillites, quartzites, and slates, because of its colour and superior resistance, is the most striking in appearance and physiographic expression found within the map-area. It even assumes prominence over the great black cinder cones and the rugged Cassiar batholith mountains.

South of the batholith area masses of the McLeod series are scattered promiscuously. There are in fact no very extensive areas from which they are entirely absent. In some parts many masses too small to be shown on the map lie between those indicated. In the southeastern part of the area in particular these small unmapped masses are abundant. Along the upper part of Little Eagle river they occur every few hundred feet.

The areas of the McLeod series are of various sizes and shapes, but are generally elongated in the direction of the structural trends. Within the limits of the map there is only one very large mass. This occurs in the batholith area. It stretches from Dease river to Eagle river and averages 4 to 5 miles in width. At the southern limit of the map-area there is a strip of these rocks which probably constitutes part of a very large mass extending for some distance to the south.

Nearly every high mountain and hill in the southern part of the map-area, with the exception of the few cinder cones, owes its prominence to the rocks of the McLeod series. These either occupy the higher parts of the hill or mountain or have clearly just recently been removed. Mount McLeod, mount Sullivan, Johnsons Knolls, French mountains, Stake, Porter Landing, Cariboo, Red Ledge, Defot, and Coulahan mountains all are capped or partly capped by rocks of this series. In the northern part they constitute mountains even higher and more rugged than the batholith range. Northwest, Sphinx and Pyramid mountains—the last the highest in the area—are of this material. Everywhere these rocks stand up prominently. As a rule even in the lower areas they support very little vegetation. The rock is generally bare and in the higher mountains has been carved into fantastic and very rugged features.

The basal member of the McLeod series in places is a conglomerate. Conglomerate mountain in the northeastern part of the map-area is made up largely of this material. East of this it is found only intermittently at the base of the series. In the southwestern part of the map-area, however, many small, isolated patches are found.

The conglomerate varies in composition according to the underlying rock. That on Conglomerate mountain contains mainly material from the Dease series, much of which is limestone. On Coulahan mountain it is made up almost entirely of serpentine from the Thibert series; on Defot it is again mainly limestone and other materials from the Dease series; and on Red Ledge it contains much from both series. In most places the conglomerate contains much limestone. Older Palæozoic rocks are also commonly represented. Serpentine as a rule is not found as pebbles, though its presence in the matrix is common. The boulders range in size up to 2 or 3 feet in diameter. The matrix is usually arenaceous, but as a rule consists partly, in some cases almost entirely, of serpentine. In places the conglomerate grades to a volcanic conglomerate whose pebbles and boulders are cemented by lavas or tuffs.

At by far the greatest number of contacts observed there was no conglomerate—tuffs, lavas, or other materials of the series were observed to overlie directly the rocks of the Thibert or Dease series. Generally, however, a few pebbles, some coarse material, or other unusual features indicate the basal phase.

The greater part of the McLeod series is a heterogeneous assemblage of volcanics—lavas, breccias, agglomerates, etc., interbedded with argillites, quartzites, and slates. Green is the dominant colour, with a wonderful variety of shades. All sorts of mottlings, blotchings, and mixtures of these are found. There are also purples, reds, greys, yellows, and browns. The variety of shades and designs is remarkable. Variations in texture are as marked. There are almost all the textures of igneous rock, from very coarse to quite dense, and of sedimentary from conglomerate to dense argillites and slates. There are agglomerates of various sorts, breccias and tuffs, and mixtures of these with the various other types of material. The dense, hard, massive, light green tuffs, argillites, and quartzites are by far the most common. In some places the rocks are entirely massive, but in most places careful examination discloses bedding. This is only rarely brought out by weathering along the bedding planes, a feature which is in marked contrast with the distinct lamination found throughout the Dease series.

Much bedded jasper occurs in the McLeod series in French mountains and on Vowel mountain. In some places this is slightly calcareous. On Thibert creek and farther east there are thick beds of grey chert or chalcedony.

Once it is understood that the apparent interbedding of the McLeod series with the Dease series is merely the retention of small masses of the younger rock in synclines it is generally not difficult to differentiate between the two series. The character of the bedding is one distinguishing feature which holds fairly consistently. The McLeod series almost invariably shows some of the massive, dense, light-green phase. The rocks of the Dease series show for the most part common sedimentary phases with nothing particularly unusual, whereas weird colours, textures, and bedding are everywhere to be found in the younger rocks.

In many places the McLeod series contains coarse-grained, igneous rock which is strongly suggestive of an intrusive origin. Some of this is undoubtedly the result of contact metamorphism induced by the Cassiar batholith. Several small areas of this type are shown within the large mass of this series in the northern part of the map-area. There are many others of the same sort, but it is probable that in some places the texture is original, though at no place could this be definitely proved.

The material found at the base of the series or overlying the conglomerate consists of flows, tuffs, breccias, and agglomerates. Under the microscope this is found to have the great variety of texture and composition that such variations in character might be expected to produce. Several peculiar phases occur at the base of the series south of Porter Landing mountain. One is a dark green, serpentinous rock with rounded, pisolite-like masses of grey material. Under the microscope it is found to be largely serpentine, and it appears to be an alteration of olivine porphyry. The mountain itself is made up of a hard, granular, green serpentine which contains large, quarter-inch flakes of a green mineral—probably also serpentine. This rock weathers rusty brown. These two phases are probably altered flows of olivine basalt and seem to represent the base of the series. As structural relationships are not clear it is just possible that these belong to the Thibert series. However, elsewhere there are flows now almost entirely altered to serpentine, which lie at the base of the McLeod series. This would seem to indicate that in some localities the base of the series is almost as, if not as, basic as the Thibert series.

Everywhere the rocks were found to be quite basic. The plagioclase feldspar most commonly determined was labradorite. Nothing more acid than andesine was noted. The feldspar content varies greatly. Some specimens were found to be almost entirely labradorite; others showed no feldspar at all, and in a large percentage it fell below 50 per cent of the total constituents. Quartz is extremely rare. It occurs in several tuffs as angular pieces. In other specimens it appears to be secondary or vein material. None could be definitely assigned to a primary origin. Olivine was found in a few specimens and its former presence in others was probably denoted by serpentine. Augite is abundant and was found in the majority of specimens examined. Hornblende was noted in only two out of twenty-three specimens, but in them it is the most important constituent. Magnetite is abundant and widespread. Its alteration to hematite produced to a large extent the red colouring of the jasper, the felsite-like material, and other rocks. The green colour is due partly to serpentine, but largely to chlorite, which coats nearly all the rocks.

The composition of the rock varies in different localities. On Porter Landing mountain it is highly serpentinous. Most of the rock specimens obtained from Thibert creek contain labradorite and augite, as do also the rocks of mount Defot. These were by far the least altered of all examined. Specimens from the large mass on Chickens Neck mountain and elsewhere show the greatest variation in composition. This is probably because a greater thickness of the McLeod series is exposed there—the rocks higher in the series being productive of andesine and hornblende and the more acid phases. Hornblende was noted only in these rocks, but andesine was found elsewhere. Some of the rocks of French mountains are exceptionally high in magnetite, scattered throughout as small grains. Others contain an abundance of titaniferous magnetite or ilmenite which is largely altered to leucoxene.

All the rocks examined microscopically were largely igneous or tuffaceous. The character of many seems to indicate clearly that they are argillites. Others are mainly chalcedony or chert. Some are slates and others appear to be quartzite. The material of which these are formed was probably largely derived from the tuffaceous and igneous rocks which must have covered the whole area.

The strata of the McLeod series, like those of all the older rocks, are very intricately folded and somewhat altered by dynamic metamorphism. Schistosity and cleavage are well developed in many places. Much of the rock is intensely altered by contact metamorphism.

Owing to the complicated nature of the structure and the difficulty in most places of obtaining any definite information about it, no accurate estimate of the thickness of the series can be made. The largest area is as much as 5 miles wide across the strike and has a relief of over 4,500 feet. These features seem to indicate that the thickness exceeds 4,500 feet—probably by several thousand feet. South of Dease lake, along both sides of the Tanzilla, rocks apparently similar extend for many miles and have a relief of several thousand feet. The thickness there must be as great as that found in the northern part of the area. However, it is improbable that, prior to erosion, the same thickness was maintained over the whole area.

The source of the material which constitutes the rocks of the McLeod series is not apparent. Dykes, stocks, or other intrusives that might be referred to the same period of igneous activity were not recognized. The tremendous thickness of the series over a great area would seem to suggest enormous vents and it does not seem unreasonable to assume that these may have been in the nature of fissures with a northwest-southeast trend parallel to the present structural axes. Whether or not the surface on which deposition took place was submerged below the sea is not apparent. Some of the deposits are undoubtedly waterlain, but these may have been formed in lakes created by damming of the rivers by lava flows.

The rocks of the McLeod series overlie unconformably the upper Triassic limestone and are cut by the Cassiar batholith. It seems probable that the age of the series is Jurassic. The rocks are similar to those of Jurassic age found at many points along the coast of British Columbia, east of the Coast Range batholith, and in the Yukon.

CASSIAR BATHOLITH

In 1887 Dawson[1] gave the name "Cassiar" to the range which crosses the northern part of the map-area. This name is here also applied to the batholith which forms the core of the range.

The Cassiar batholith occupies the greater part of the northeastern section of the map-area. It has a northwest-southeast trend. Beyond the area it is reported to extend far to the southeast, probably to the headwaters of Finlay river; to the northwest it is said to continue for 80 miles or more. This mass, therefore, may be considered as a batholith, the exposures of which probably extend for a distance of 200 miles. Its general trend converges to the north toward the Coast Range batholith. The width of the exposures within the map-area ranges from 20 to 25 miles. Beyond the limits of the main exposures no associated masses were discovered within the map-area. A few exposures are isolated in sedimentary rock, but are probably separated from the main mass by only a very thin shell. Within the batholith area there are many small and one large inclusion of sediments and volcanics which undoubtedly represent part of the original roof of the igneous mass.

Physiographically the batholithic area presents two entirely different aspects—rugged high mountains and relatively flat lowlands. In the north the batholith constitutes a large part of the Cassiar range. The rocks form a series of sharp peaks and rugged saw-tooth ridges with an elevation mainly between 6,000 and 7,000 feet and a relief of nearly 4,500 feet. South of the range there are great areas of the batholith which constitute part of the plateau and show little relief except near Coulahan mountain where they form several, well-rounded mountains, and near Spike mountain where they in part constitute a high and rugged ridge.

The most striking and confusing feature of the Cassiar batholith is the great variety of the material which constitutes it. At first the impression was gained that the mass is an igneous and metamorphic complex made up of many intrusives and many different groups of metamorphic rocks. Yet sharp contacts between these are extremely rare, various phases as a rule appearing to grade into one another. Some rock phases which appear to be intrusives grade into the volcanics of the McLeod series and, therefore, coarse, granular phases of volcanics near the batholith may or may not belong to the batholith. The contact of batholithic

[1]Op. cit.

rocks with sedimentary rocks could not be defined. In places, owing to the gradational metamorphism, it was found impossible, within a zone of several hundred feet, to determine definitely where igneous rock ends and where sedimentary rock begins. Very basic material was found grading into very acid material. There is no phase which may be said to be typical of the batholithic mass. No reasonable solution of the problems involved can be made, nor an adequate description be given without conceiving of the part of the mass exposed as having been formed largely by assimilation of the intruded rocks.

The present surface of the batholith in the area south of the Cassiar range appears to be not far below the original roof, for at many places there are inclusions of unaltered or only partly altered sediments and volcanics of the Dease and McLeod series. Most of these were mapped as part of the batholith. The body of sediments which occupies the area just north of Dease lake is believed to be only a relatively thin shell overlying the batholith, for it is pierced in many places by small masses of igneous rock. The great mass of sediments and volcanics surrounded by the batholith in the western part of the area is of considerable thickness, but to the east is thought to thin out. Within it even on the highest peaks there are small areas of plutonic rock. At other points, notably north of Northwest mountain and on Chickens Neck mountain there are areas of highly metamorphosed sediments and volcanics which clearly testify to the proximity of the igneous rock below.

From these and other features some idea of the configuration of the original surface of the batholith mass can be obtained. In general it is irregular, and within the present area of exposure, before erosion cut into it, must have had a relief far exceeding 7,000 feet, yet in some places must have had a relatively flat upper surface over considerable areas. At Anvil mountain it is clear that the contact with the sediments is nearly vertical for at least 4,000 feet. At other places in the mountains small areas of the batholithic rocks are evidently the surface expressions of long, wedge-like or even plug-like masses. On the other hand, north of Dease lake the presence of many igneous masses scattered through the sediments seems to indicate that in this small area the batholith has a fairly even upper surface.

The main mass of the batholith lies in the Cassiar range and was examined very hastily. The information gained seems to indicate that this part of the batholith has the same general aspect as the western part and there is nothing to indicate that a greater thickness of igneous rock was removed in the mountain region than to the south. Similar variations in character of material in the parts examined were noted. This condition possibly does not indicate proximity to the batholith roof, for the same heterogeneity obtains, so far as known, everywhere, even at places known to be thousands of feet within the mass.

With the exception of many masses within the area north of Dease lake and two others indicated on the map, practically no outliers and not even dykes were found in the southwestern part of the map-area. There is no evidence to indicate at what depth the batholith may underlie such areas. The dip of the southwestern contact as observed on Coulahan mountain and elsewhere is very steep. This is also the case with the northern contact at the mouth of Cottonwood river.

The material composing the batholith, as defined on the map, varies greatly in character, since it includes rocks which range from those with the aspects of plutonics to others which are only partly metamorphosed sediments or volcanics. It ranges in colour from dark green to a light grey, white, pink, or red, being mainly either light grey mottled with black, or dark green mottled with a little grey. In texture there seems to be almost every conceivable phase of megascopically granular rock; pegmatitic, aplitic, porphyritic, fine and coarse, and every gradation between these and those of the sediments and volcanics. Included in the batholith are typical sediments and volcanics with large mineral masses developed within them. There are great areas of mica-feldspar-gneiss, hornblende-feldspar-gneiss, and many other varieties which are suggestive of dynamically metamorphosed igneous or sedimentary rocks. There are also schists, though most of these have been mapped as belonging to the pre-batholith formations.

Megascopically compositional variations are pronounced: green rocks are largely hornblende or augite, and some of the white contain as much as 90 per cent of quartz. Biotite, hornblende, and augite occur in large crystals. In some specimens round grains of quartz resembling sand grains protrude from a crystalline matrix. Large masses of feldspar suggest pegmatite veins.

Some of the rock is hard, massive, and quite fresh in appearance. Some is rotten and crumbles as if badly weathered and yet probably has not been subjected to more severe conditions than the least weathered. In places the rock has broken at the surface into small pieces which have green and red slickensided faces. Gneissic, schistose, and even-bedded varieties occur.

Over thirty specimens were examined microscopically. Most of these were collected in the area between Coulahan mountain and Spike mountain. A few were obtained in the area extending for 2 miles north of the contact at Joe Irwin lake and about half a dozen came from various points in the eastern part of the area. Six specimens from the mountains east of Joe Irwin lake included one quartz granite or granodiorite (quartz over 90 per cent, orthoclase, oligoclase, and biotite) and five granite or granodiorite with the same kind of minerals in varying proportions. The rock here and on Anvil mountain is of a light grey colour. From Spike mountain one specimen was found to be granodiorite (75 per cent andesine (?), quartz, orthoclase, hornblende, and biotite); another granite (orthoclase 45 (?) per cent, quartz 45 (?) per cent, and oligoclase) and a third a hornblende-gabbro (hornblende 50 per cent, plagioclase, and quartz). The first two are light grey and the last is green. Four specimens, two from the north side of Thibert creek above the delta and two from the hill north of Beady creek, are granite, granodiorite, or quartz diorite (mainly andesine, orthoclase, quartz, and biotite). All these, like most of the rocks in the same localities, are light grey. One specimen collected just west of Porter Landing in the isolated mass cutting the McLeod series is green and either diorite or gabbro (hornblende 35 per cent, no quartz, augite (?), plagioclase, either andesine or labradorite). One specimen from Thibert creek just above the delta near a spur of the McLeod series was found to be granogabbro (approximate composition:

labradorite 50 per cent, orthoclase 25 per cent, quartz 25 per cent), and another, collected a little farther west, is granite (orthoclase, oligoclase, quartz, biotite, and hornblende). Just above the little mass of the Dease series about 5 miles up the creek, granite (quartz, orthoclase, oligoclase-albite, and hornblende) is found. In the vicinity of Coulahan mountain all the rock of the batholith is distinctly green and is gabbro or quartz gabbro (bytownite, hornblende, augite, quartz, and magnetite). At Slough mountain it is quartz diorite or quartz granodiorite; in the valley of Canyon creek it is variable in character. Northwest of Slough mountain there are probably more abrupt changes in character than at any other place. Farther down Canyon creek the rock is mostly green and consists partly of gneiss. Two specimens were determined; one as tonalite (with oligoclase) and another as meta hornblende-gabbro (hornblende over 75 per cent with a little plagioclase—possibly bytownite). Northwest mountain and the isolated masses in the McLeod series are green and probably basic in composition. It is important to note that the basic character is almost invariably found only near the rocks of the Thibert and McLeod series. The acid character is more common throughout because the igneous rock is mainly due to assimilation of the highly quartziferous sediments of the Dease series. The rock as a whole may be described only as varying in composition from granite to meta hornblende-gabbro.

Within the batholith there are three areas largely of mica schists, associated with materials very similar to the Dease series with which, therefore, they are correlated. In the area of this series north of Dease lake the effects of metamorphism are seen, though they are not as pronounced as in the other areas. It was not possible to trace the various stages of metamorphism and the early stages were not noted anywhere. The quartzitic slates, argillites, and schists are altered mainly to mica schists, the mica being segregated more or less into laminæ. Between the laminæ there is granular quartz and probably feldspar. With an increase in quartz content the rock is less schistose, though the mica flakes are as a rule oriented parallel to the lamination and the whole in many cases presents a gneissic structure. In the quartzites the biotite flakes are developed without any definite orientation. Gradations from these various phases to the rocks of the batholith were noted.

Limestone containing long crystals of pyroxene was found north of the batholith on Dease river. This is the only alteration of limestone observed which might be attributed to the batholith.

Small masses of the batholith occur at several places within the areas of the McLeod series and at these places there appears to be an unbroken gradation from rocks such as form the McLeod series to others which are clearly plutonic. In the valley of Canyon creek there are large areas of green gneiss somewhat similar to rocks observed elsewhere, with a coarsely granular, typical igneous texture. Gradations between the gneiss and the granular, igneous rock were observed and also between the gneissic rock and typical volcanics. On Coulahan mountain the gradations are from a green plutonic rock to the basal conglomerate of the McLeod series. On Chickens Neck mountain a large area of the light green, volcanic material is altered to a vaguely granular rock of the same colour without gneissic texture. In places hornblende schists have been developed.

The batholith cuts rock structures that are probably Jurassic in age, thus seeming to indicate that intrusion or assimilation continued after the Jurassic deformation was completed. It is possible, therefore, that the batholith is Cretaceous in age.

Owing to the complex nature of the batholith it is difficult to ascertain what changes have been effected since its formation. A certain amount of cataclasm of the quartz, irregular shattering, slickensiding, and other features seem to indicate that it was involved in deformation. It was probably subjected to some shattering prior to or during the Tertiary era.

BEADY FORMATION

A conglomerate which bears no close resemblance to any other formation in the area occurs south of Beady creek and north of Porter Landing mountain. It is found mainly as large, detached blocks several feet in diameter, but a few masses seem to be in place. It can be traced as a narrow band for a mile or more along the base of the mountain and is probably not much more extensive than this.

The material consists of well-worn, rounded pebbles and boulders in a sandy matrix and is a waterlain deposit. The boulders, some of which are as much as 6 inches in diameter, are mainly of local materials. Granite of the type found on the north side of Beady Creek valley is abundant, as are also argillites and volcanics of the McLeod series, and slates, quartzites, and other rocks of the Dease series. No limestone, carbonate tuffs, or serpentine were observed. More abundant than any of the materials which can be assigned to their sources is a brown sandstone similar to the matrix of the conglomerate. This sandstone is made up of materials similar to those which constitute the boulders and is probably of the same age as the conglomerate.

The conglomerate is not altered, squeezed, nor sheared. Bedding is apparent only rarely and where present gives no definite idea of the structure of the formation, but suggests that the rocks have been folded and in part dip to the north. The age of the formation is post-Cassiar batholith and pre-Pleistocene. It is probably either late Cretaceous or early Tertiary.

TUYA LAVAS AND CINDER CONES

A great plateau known as Level mountain extends to the west of Dease Lake area. Tuya lake, 9 miles northwest of Coulahan mountain, occupies the northeastern corner of this area. Level mountain is reported by prospectors and other travellers to be capped largely by lava flows. Viewed from a distance it appears remarkably flat except for a number of huge, black mountains which have the appearance of enormous volcanic cones. These are probably the source of the extensive Tuya lavas. Other similar cones are reported to lie south of Stikine river, whose valley just below Telegraph creek and for many miles above it is partly filled with lava flows which have been described by G. M. Dawson.[1]

The igneous activity which expressed itself to such a marked degree to the west and southwest of Dease lake also had its influence within the map-area. In many places the batholith and older rocks are cut by fresh,

[1]Op. cit.

dark grey, basaltic dykes. In places bodies of volcanics occur, ranging in size from very small masses that form dams across the streams to huge cones which are one of the outstanding topographical features of the area. In the upper part of Canyon creek a tongue of the great Tuya lava field extends into the map-area.

The lava flows observed on the Stikine and on Canyon creek assume the form of frozen streams filling old valleys and cut through by new. Other extrusives, with the exception of the small masses and the large one in Eagle River valley, which are relatively flat and low, constitute prominent topographic features. They are black mountains with a relief of 1,000 feet or more, and have abrupt slopes which meet in knife-edge ridges or sharp, conical points. They support little vegetation and in some places are almost inaccessible because of their long, steep talus slopes and extreme ruggedness. From even a short distance they present an aspect not unlike modern volcanoes.

The lava flow in the valley of Canyon creek is about 40 feet thick. In the valley of the Stikine as many as five flows were noted. The time which intervened between the formation of the upper two was sufficient to permit of the development of valleys which in places cut through four of the flows. The flows range in thickness from 10 to 50 feet and show the columnar jointing common to basalts. They are horizontal and judging by their location in valleys were poured out on a surface similar to the present. The molten material must have been very liquid, for it flowed many miles in relatively narrow and shallow streams. These narrow streams probably represent tongue-like protrusions from the great lava fields which occupy the plateau country west and southwest of the map-area. That the lava was extruded from a large number of pipes and small fissures rather than from one big fissure is certain because the location of many of the feeding channels is still apparent. All the cones observed derived their material from a pipe or small fissure located near the centre of the mass. In some the pipe is still apparent, extending to the top of the mass. Slough mountain is made up almost entirely of extruded lavas cut by dykes. The southern part of mount McLeod is a series of inter-bedded lavas and tuffs with other volcanic ejecta. Of the three masses in the southeastern part of the area one is similar to Slough mountain; the other two are of the McLeod type.

The dykes which are found in all parts of the area are as a rule small, rarely exceeding 10 feet in width. They are quite fresh and are in no way deformed.

The rock of the flows is mostly dark grey or black, in places with a distinct greenish tinge. The Canyon Creek lava is finely crystalline, with a peculiar open-work texture which is due to inter-crystal cavities. A few blebs of green, glassy olivine are scattered through the rock. At the base of the flow the rock is somewhat denser and as a rule scoriaceous. The lavas of the cones and other masses are similar to these, though they show more variations in texture and are for the most part scoriaceous. The dykes are somewhat similar but are more compact, in some places more coarsely granular, and in many porphyritic with white feldspar and green hornblende phenocrysts.

All the specimens examined microscopically are basalts. The Canyon Creek lava consists of: augite 10 to 15 per cent, olivine 20 to 30 per cent, bytownite 60 to 70 per cent, and magnetite 3 to 5 per cent. A specimen from the small Berry Creek mass and another from mount McLeod were found to have a composition very similar to this. A Beady Creek dyke has in addition to the above minerals basaltic hornblende, and one on Dease creek contains a large percentage of this mineral in a badly altered groundmass. All are quite basic: olivine, augite, and magnetite are abundant and the feldspar[1] is generally bytownite, though in some less basic.

Associated with the lavas are other types of volcanic ejecta. Tuffs are abundant and in one or two of the cones predominate over the lavas. They are softer and lighter than the solid rock, but are held together by a network of dykes. They weather readily and in many places, due to the high magnetite content, are quite rusty. Volcanic breccias and agglomerates are found in some of the cones. On one of these in the southeast, olivine bombs lie scattered about as if just recently ejected. These are as a rule about the size of a fist and have black scoriaceous surfaces. The interior is entirely green, granular olivine.

Gravels and sand underlie the lavas and tuffs in places and in a few cases are interbedded with the flows. Occasionally they are quite firmly cemented.

The presence of glacial drift even on the top of the volcanic cones clearly indicates that they were subjected to some Pleistocene glaciation. However, in many cases it does not seem possible that they could have withstood as much glaciation as have some of the older rocks. At one place a contact with these was observed. This was so fresh and unweathered as to suggest a glaciated surface. Gravels included in the base of the flows, however, were not found to be glaciated.

The lava beds in Canyon creek and along Stikine river show little effect of glaciation and some retain a surface which is strongly suggestive of the original flow surface. They lie in valleys transverse to the direction of ice movement and, therefore, would be protected to some extent from ice erosion. Hot springs are reported to be fairly common around the base of the volcanic cones south of Telegraph Creek. All these features suggest that some of the flows are younger than Miocene, to which they were referred by G. M. Dawson.[2] It is thought that the lavas and cinder cones within the area are very late Tertiary or early Pleistocene and it would seem probable that they represent only part of a period of volcanic activity which in the general region of northern British Columbia began in the Tertiary and continued into the Pleistocene.

STRUCTURAL GEOLOGY

The geological structure of Dease Lake map-area is very complicated, owing to the fact that there were several periods of deformation, one of which was exceptionally intense. There was deformation at the end of the Permian, Triassic, Jurassic, and, probably, Cretaceous periods. In addition, there were periods of regional uplift, faulting, and possibly of

[1]Feldspars according to Johannsen—"Essentials for the Microscope Determination of Rock-Forming Minerals and Rocks."

[2]Geol. Surv., Canada, Ann. Rept., vol. III, pt. I (1887) and Pub. 629 (1898).

doming. Owing to lack of sufficient areas of Cretaceous sediments the nature of the deformation following this period is not definitely known and owing to the great intensity of the Jurassic folding the orginal nature of the older structures is difficult to interpret. The present structure is probably largely a result of the Jurassic deformation.

The folding is so intricate that strikes and dips are of little value in determining major structural features. A continuous section up streams like Dease creek or Little Eagle river gives a series of strikes and dips which, unless plotted in great detail, have little meaning other than to indicate the complicated nature of the folding and in places the general trend of the folds. As a consequence very little was learned of the structure in those areas where the Dease series alone occurs. It was only by a careful mapping of areas of the younger formations and a study of their distribution that some definite knowledge was obtained. Fortunately many of these areas are found in the higher peaks and it was possible to observe actual cross-sections in the cliffs and abrupt slopes. French mountains afford an excellent opportunity for study of the structure and it was by means of sections exposed there that it was possible to make fairly accurate determinations of the structure. The base of the McLeod series at this locality and in most other places was used as a datum plane in working out the various structural features.

The strata are involved in a series of small folds, very few of which exceed half a mile from synclinal to anticlinal axis. These are grouped in indefinite, flat anticlinoria and synclinoria. Neither the small folds nor the larger composite folds show any very definite form, shape, or size. In a large part of the area they trend nearly parallel to the batholith, but in the south-central part they are more nearly at right angles to it.

The dips of the axial planes of the minor folds differ considerably, not only from one part of the area to another, but in places from fold to fold. Their relationship to the major folds is not consistent and they may converge or diverge in either anticlinoria or synclinoria. Laterally, also, they are variable to the extent that a 50 or 60 degree dip south changes to a similar dip north in 6 miles along the strike. In some cases folds are overturned in one direction at one place and in the opposite direction at another place not far distant across or along the strike. The plunge of these folds was definitely noted at only a few points because the younger rocks occur mainly in the higher peaks. In some places it can be seen clearly, however, that the folds are nearly horizontal for considerable distances, whereas in other places they plunge steeply.

There are composite folds which are recumbent, some to the north and others to the south. There are fan folds and other types. They have no definite system and, as is clearly shown by the French Mountain structures, are not usually continuous for any great distances.

Small masses of the McLeod series are scattered throughout the south-eastern part of the area. This distribution indicates that the base of the McLeod series after folding had no great areas of relative depression or uplift. Though extremely irregular in detail the structure in general is remarkably flat over the whole area. Structural contours would show many irregularities, but little relief.

Two periods of deformation previous to the Jurassic are clearly represented in the rocks of the area, one post-Triassic and the other post-Permian. Owing to the complicated structure developed during the post-Jurassic deformation it is difficult to evaluate fully the effects of these.

All three periods of deformation are thought to have developed structures with approximately the same trend, but with an increase in the amount of deformation from the earliest to the latest. None shows any relationship in development to the batholith. Post-Cretaceous deformation or deformations have probably had some influence on the structure, but what it was is not clear. Only one definite fault was observed. It cuts Rath mountain from east to west almost vertically. The north side has moved up over 100 feet relative to the south. Faulting may have preceded or accompanied the Tertiary igneous activity. Probably it was not of great importance. No earlier faults were noted, but it is not improbable that some thrust faulting accompanied the post-Jurassic deformation.

ECONOMIC GEOLOGY

Placer gold in quantities of economic value has been found in the map-area in the following streams: Dease creek (in the first 8 miles above the lake); Thibert creek (mainly in the first 8 miles above the lake, but also higher up and in some of the tributaries—Vowel, Frying Pan, French, Mosquito, and others); Defot creek; Porcupine creek; and Goldpan creek. The veins from which the gold was derived have not been discovered. It is probable that in all cases the larger quantities have originated locally, mainly as a result of pre-Pleistocene erosion. The presence of much rust in the cavities of the nuggets and the fact that quartz in many cases forms parts of the nuggets seem to indicate that the gold was derived from the upper oxidized parts of quartz-sulphide veins. Sulphide veins were observed, but did not show a gold content upon analysis. The sulphides were largely chalcopyrite with some pyrite. The concentrates from sluice-boxes on Dease creek are mostly arsenopyrite and pyrite, which would seem to indicate the presence of veins containing these minerals. It is not improbable that arsenopyrite veins carrying gold in small quantities represent the original source of the placer gold. The veins need not have been either very rich or large, for the amount of material from which the mineral was derived may have been very great.

The distribution of the areas in which the placer gold occurs—and presumably the veins from which the gold was derived—does not bear a definite relationship to the batholith as exposed. The veins, however, may have been offshoots from the parts of the batholith which were more liquid and which underlay at no very great depth the gold-bearing areas.

Only four or five mineralized veins were observed during the whole field season. In the eastern part of the area one small vein carrying pyrite and chalcopyrite was found. Analysis of one picked specimen gave 13 per cent copper and of another less than 1 per cent. Both showed a trace of silver and no gold. Other veins carrying pyrite alone were found. None of these veins is likely to be of economic value.

Platinum, chromite, ilmenite, magnetite, and manganese carbonate are found in the streams besides the placer gold. Platinum has been collected in very small quantities with the gold from Thibert creek. It probably came from intrusive phases of the more basic lavas of the Thibert and McLeod series, though no such phases were observed. The small quantities collected probably represent a considerable concentration and they may have come from some distance. The other minerals found in the stream gravels are all very similar—black, hard, and heavy. In the quantities obtained they have no economic value. Chromite, ilmenite, and magnetite are found in the altered lavas. The very large pieces probably are derived from intrusives.

Asbestos occurs in some of the serpentine, but in very small veins of no economic value. Intrusive phases of the lavas, however, may afford possibilities of a better supply.

Rusty brown rock which is called "porphyry" by a large number of prospectors is abundant in the area. No true porphyries of a brown colour were observed. By far the greater part of the rusty brown rock is carbonate-serpentine tuff found at the base of the Thibert series. Owing to the nature of the folding, it in many places has the appearance of dykes. There are several occurrences in the Dease series of rusty brown, dolomitic beds. There are also some brown or red phases of the batholith which occur in places in dyke-like masses. A "porphyry dyke" is reported to occur 8 miles up Dease creek. Rock fitting the description of this dyke was not noted in the parts traversed, but owing to its precipitous walls the valley was not followed continuously. There are porphyry dykes of Tertiary age and brown dolomitic beds in the Dease series, one of which may be what is meant by the term. At several places the rusty brown rock has been staked as mineral claims, but none of that observed is likely to contain, or to indicate the presence of, minerals of economic value.

So far as is known there are no deposits except the placers which are likely to be of economic value, nor is there any direct indication that such deposits are likely to be discovered. The area has been subjected to much igneous activity, but there was very little of a type which might produce mineralization, at least to any great extent. The part of the Cassiar batholith which is exposed within the map-area is not likely to have mineralized veins associated with it. The presence of placer gold, however, shows that some mineralization in the adjacent rocks does occur.

RECONNAISSANCE IN ZYMOETZ RIVER AREA, COAST DISTRICT, B.C.

By George Hanson

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Illustration

Map 2098. Zymoetz River area, Coast district, B.C. .... In pocket

INTRODUCTION

The area lying between Smithers, on Bulkley river, and Terrace, on Skeena river, here designated Zymoetz River area, has not hitherto been mapped geologically. The Geological Survey has done work along the borders of the area, along Bulkley, Skeena, and Telkwa rivers, but practically the only published references to the mineral deposits of the interior of the area are contained in the Annual Reports of the Minister of Mines of British Columbia. In 1925 the writer made a geological reconnaissance of the area.

R. H. B. Jones, J. L. Ramsell, S. Gibson, and R. A. Henderson rendered able assistance in the field. Mr. Jones did independent work on Hudson Bay mountain, a part of the area, and a report by him dealing with this section appears in this volume. The writer wishes to acknowledge his indebtedness to J. R. Turner, J. D. Wells, and other mining engineers and prospectors encountered during the summer, for courtesies and assistance.

The Canadian National railway affords access to the eastern and western sides of the area. A good road suitable for automobiles extends westward from the railway at Smithers for 14 miles and continues for another mile as a wagon road. From the end of the wagon road a good horse trail extends to Coal creek, 20 miles farther west. A trail also extends westward from Telkwa for 30 miles. On the western side of the area trails suitable for horses extend up Zymoetz river, and Kleanza, Chimdemash, and Legate creeks.

The trails along Kleanza creek and Zymoetz river formerly reached to Bulkley river at Moricetown by way of upper Zymoetz river, and to Telkwa by way of Telkwa river. During the last twenty years, however, these trails have not been used as through trails, and the central parts, 35 miles long on the Zymoetz River trail and 15 miles long on the Telkwa trail, are now impassable. The central part of the area can be reached only by travel through dense bush.

PHYSICAL FEATURES

Zymoetz River area is situated in the transition zone between the Coast Range mountains and the Interior Plateau. The area is mountainous and is in the main extremely rugged, containing many steep-sided mountains with pinnacled peaks rising as high as 8,500 feet above sea-level.

Zymoetz river drains the greater part of the area and it occupies an old valley of river erosion which has been modified to some extent by glaciation. This stream heads on Hudson Bay mountain in a lake 6 miles west of Bulkley river and flows westward into Skeena river at Copper River post office. From its head it flows due west 24 miles, then due south for 20 miles, and then westward for 22 miles to where it reaches Skeena river. From Aldrich lake at the head of Zymoetz river to Dennis lake, a distance of 3 miles, the river is a slow-moving, marshy stream. From Dennis lake to MacDonnell lake, a distance of 6 miles, the river falls 15 feet a mile. From MacDonnell lake to its mouth the river falls 2,300 feet, with an average grade of 36 feet a mile, except for cascades, and falls 40 feet high 6 miles from the mouth of the stream. Glaciers are situated at the heads of several of the tributaries of the river, so that the stream is in flood not only in rainy weather but also in hot weather, through the rapid melting of ice.

The southerly-trending part of Zymoetz River valley divides the area into a western and an eastern part. The western part is drained chiefly by creeks, each approximately 15 miles long and flowing westward into Skeena river. These are Kleanza, Chimdemash, St. Croix, Legate, and Oliver creeks. A low pass extends eastward to Zymoetz river from the head of Kleanza creek, but the other creeks head in high mountains. The creeks flow in deeply-incised valleys of stream erosion, somewhat modified by glacial action. The eastern part is drained chiefly by Telkwa river, which flows eastward to join Bulkley river at Telkwa. The area north of the upper part of Zymoetz river is drained mainly by Kitsequekla river, which flows northward into Skeena river at Skeena Crossing.

The creeks flowing westward into Skeena river form dividing lines between westerly-trending mountain ridges. These ridges are 4,000 to 6,000 feet high in general, but serrated peaks rise above 7,000 feet. A southerly-trending mountainous ridge in which Telkwa river has its head, lies east of the north-south part of Zymoetz river and continues south on the east side of Kitnayakwa river. The top of this ridge is 8,000 feet high and several peaks are 9,000 feet high. Between the upper part of Zymoetz river and Telkwa river a flat-topped ridge extends eastward from the southerly-trending mountainous ridge previously mentioned. This ridge decreases in elevation from 8,000 feet at its western end to 5,000 feet at its eastern end, where it descends more steeply toward Bulkley valley. North of upper Zymoetz river, between Coal and Pass creeks, is a low-lying, wooded area with many small lakes, and, where the hills rise, only 4,000 feet above sea-level. This comparatively low area is crossed from south to north by several low passes between Zymoetz and Kitsequekla rivers. To the east of it is a large, high, isolated mountain mass. This is Hudson Bay mountain and because of its height (8,700 feet) and isolated position it is a conspicuous landmark which can be seen from points many miles away.

The low-lying parts of Zymoetz River area are in general underlain by soft rocks and the upstanding parts and mountains by hard, resistant rocks. The lakes occupy depressions left by retreating ice and consequently date from the Pleistocene. Some evidence bearing on the date of origin of the main valleys is furnished by the distribution of the Skeena formation of Lower Cretaceous age. This formation is confined to the Telkwa, Bulkley, Skeena, and Zymoetz River valleys and everywhere lies below an elevation of 4,000 feet. In Zymoetz River valley the formation rests unconformably on Jurassic rocks. It does not seem likely that the Skeena formation was downwarped or downfaulted to its present positions, but that it was deposited only or mainly in ancient valleys of erosion which, since they thus came to be occupied by relatively soft, easily eroded strata, determined the general course of the main drainage of later Mesozoic and subsequent time. From these assumptions it follows that the main river valleys of the region in the vicinity of Zymoetz River area may have originated in part in very late Jurassic or earliest Cretaceous time.

GENERAL GEOLOGY

Zymoetz River area occupies a medial position in a long belt of Mesozoic rocks that on the east borders the Coast Range batholith from Portland canal to Dean river. The rocks of the area are chiefly Jurassic tuffs, breccias, and flows. Sedimentary rocks occur in minor amounts, but are more plentiful in adjacent areas farther north. Remnants of a Cretaceous sedimentary formation are present in the main valleys. Granodiorite, diorite, and related intrusives are common in the southwestern part of the area. Pre-Jurassic sediments occur, but are not common. Dykes of granodiorite, alaskite, and lamprophyre occur and locally are very numerous.

Table of Formations

Period	Formation	Lithology
Recent		Gravel, sand, rock debris
Pleistocene		Boulder clay, morainal material
Lower Cretaceous	Skeena formation	Shale, argillite, sandstone, conglomerate, coal (fossils)
Upper Jurassic to post-Lower Cretaceous		Alaskite, lamprophyre, and granodiorite dykes
Upper Jurassic	Coast Range batholith	Granodiorite, granite, diorite, gabbro, syenite, quartz porphyry (stocks and batholiths)
Upper (?) Jurassic	Hazelton group	*Upper Sedimentary division* Argillite, quartzite, conglomerate (fossils) *Upper Volcanic division* Tuff, breccia, lava flows, sills, rhyolite, andesite, rare limestone, and argillite
Lower Middle Jurassic		*Middle Sedimentary division* Argillite, quartzite (fossils)
Lower (?) Jurassic		*Lower Volcanic division* Lava flows, breccia, red tuff, andesite
Triassic and Carboniferous (?)		Cherty quartzite, argillite, crystalline limestone, conglomerate (fossils)

Carboniferous (?) and Triassic

Rocks of Triassic age are present in the southwestern part of the area, in Zymoetz river and Kleanza creek. These rocks consist of heavy beds of crystalline limestone, thinner beds of cherty quartzite, slate, and argillite. Chert-pebble conglomerate and limestone-boulder conglomerate also occur. The crystalline limestone is usually white, but in places is slightly bluish. The argillite and cherty quartzite in many places are interbedded and there the bands of light grey chert grade rapidly into the alternating, equally thin bands of dark, bluish grey argillite. The chert-pebble conglomerate contains a few pebbles of volcanic rock, as well as those of chert. The boulders in the limestone-boulder conglomerate are as large as a man's head and are fairly well rounded. Closely associated and possibly contemporaneous with these sedimentary rocks are some beds of breccia and tuff.

The contact between this series of rocks and the volcanic rocks of the Hazelton group was not seen. The sediments are older, but it is not known whether or not the two series are conformable. The pre-Jurassic sedimentary rocks appear to be present in large fault blocks, since though the attitude of the strata is fairly uniform in any single area, it differs from area to area.

Fossils were collected from the limestones and argillites of the series and also from the boulders of the limestone-boulder conglomerate. E. M. Kindle has submitted the following report on the fossils from the limestone-boulder conglomerate.

"The collection contains the following fauna:

Crinoid stems
Zaphrentis cf. *beyrichi* Rothpletz
Marginifera spitzbergiaria? cf. *Postula horrida*
Marginifera cf. *slendens* Norw. and Prot.
Camarophoria cf. *superstes* Vern
Camarophoria sp.
Spirifer cf. *faseiger* Keyserl
Spiriferella arctica (Houghton)
Schizophoria ? sp.
Cliothyridina sp.

"This fauna is notably unlike any late Palæozoic fauna which is known in the eastern part of British Columbia, but appears to be identical with a widely distributed Alaskan fauna.[1] In discussing the correlation of the southeastern Alaskan occurrence of this fauna I have indicated its equivalence to the faunas of the McLeod limestones of California and the suggestion is made that it would probably be found in the Cache Creek series of British Columbia.[2] This fauna in Alaska has been referred both to the Upper Carboniferous and the Permian. I am in agreement with Dr. George H. Girty in referring it to the Permian."

F. H. McLearn reports *Daonella* sp. from the argillites of the series, and states that this form is of Triassic age.

The boulders of the conglomerate were derived from a Carboniferous or Permian formation and the conglomerate may have formed in Triassic time.

[1]Kindle, E. M.: Bull. Geol. Soc. Am., vol. 19, p. 338 (1908).
[2]Kindle, E. M.: Jour. Geol., vol. 15, pp. 335-336 (1907).

Hazelton Group

Rocks of the Hazelton group underlie 90 per cent of the area. The group, which may be over 10,000 feet thick in this area, consists mainly of tuffs, breccias, and flows, of which the finer-grained, fragmental members have been assorted by water. Near the middle of the group is a series of argillaceous sediments approximately 500 feet thick, which contain marine fossils of lower Middle Jurassic age. At the top of the group is another series of argillaceous sediments approximately 1,000 feet thick, which may also be in part at least of marine origin.

The Hazelton group in Babine mountains has been subdivided into four divisions.[2] In Zymoetz River area the relationships are not clear, but the four divisions appear to be represented with an additional division, the sediments at the top of the group. Sediments occur at about the same horizon in Babine mountains, but not in any great volume. The counterpart of the intrusive rhyolites and quartz porphyries found in Babine mountains is also present in Zymoetz River area, but was not mapped separately.

Lower Volcanic Division. Practically all of the volcanic rocks in the western part of the area, some of the volcanic rocks on Hudson Bay mountain, and probably the volcanic rocks south of upper Zymoetz river, belong to this division. On Hudson Bay mountain the upper part of the division is exposed and consists of fine-grained, well-stratified, red tuffs 500 feet thick lying conformably below marine sediments. Below the red tuffs are tuffs, breccias, and lava flows, perhaps 4,000 feet thick. These rocks are mostly brown, yellow, and reddish-purple and consist of material of andesitic composition. Some of the lava flows are scoriaceous.

The rocks south of upper Zymoetz river are mainly stratified tuffs and breccias and resemble the rocks of the lower part of the division on Hudson Bay mountain.

In the western part of the area the volcanic rocks are similar to those of the lower part of the division on Hudson Bay mountain. The rocks appear to be of andesitic composition. Lava flows are less common than tuffs or breccias and the fragmental rocks are in general fairly well stratified. In the western part of the area the division is underlain by older rocks. The exact relationship could not be ascertained, but an unconformity is probably present. The rocks at the base of the division are in no wise different from those found elsewhere in the division, with the exception of the upper 500 feet on Hudson Bay mountain. The reddish colour of the rocks appears to be due to hematite, present chiefly between rock and mineral fragments in tuffs and breccias and in interstitial spaces between crystals in lava flows.

As this division underlies rocks of lower Middle Jurassic age it may be mainly of Lower Jurassic age.

Middle Sedimentary Division. Rocks of this division are exposed in two localities on Hudson Bay mountain and are probably present near MacDonnell lake. The division consists of argillites, quartzites, and argillaceous quartzites in beds usually several feet thick, but in some places thinly bedded. The argillites are commonly dark grey to black and the quartzites light grey.

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[2]Hanson, George: "Driftwood Creek Map-area, Babine Mountains, B.C."; Geol. Surv., Canada, Sum. Rept. 1924, pt. A, p. 26.

On the western flank of the central part of Hudson Bay mountain these rocks are present in an asymmetric syncline and the upper part of the series has been eroded away. On the northern side of Hudson Bay mountain another small area of the series occurs again, apparently present in an asymmetric syncline with the top of the series eroded away. Approximately 500 feet of the series is exposed. Rocks of this division were not seen elsewhere in the area by the writer, but in 1915 J. D. MacKenzie collected fossils from similar rocks one mile below MacDonnell lake. The fossils appear to belong to an horizon near that determined by fossils on Hudson Bay mountain and may be of lower Middle Jurassic age.

Fossils were collected from the rocks of this division on Hudson Bay mountain and have been examined by F. H. McLearn, who has submitted the following report.

"From talus of middle sedimentary division of Hazelton group near Silver lake, Hudson Bay mountain, B.C."

Serpula socialis Goldfuss
Ctenostreon gikshanensis McLearn
Lima tizglensis McLearn
Oxytoma submcconnelli McLearn
Ostrea weegeti McLearn
Perna weelaupensis McLearn
Plagiostoma hazeltonense McLearn
Trigonia guhsani McLearn
Trigonia (3 species *clavellatae* section)
Modiolus sp.
Pecten sp.
Gervillia sp.
Gryphaea sp.
"*Rhynchonella*" sp.
"*Turritella*" sp.
Belemnites sp.
Sonninia hansoni McLearn
Sonninites silveria McLearn
Sonninites skawahi McLearn
Guhsania bella McLearn
Guhsania ramata McLearn

Rico Aspen property, Hudson Bay mountain, B.C., in Hazelton group.

Ctenostreon gikshanensis McLearn
"*Sonninia*" sp.

The Silver Lake fauna is of middle Inferior Oolite or Bajoician or lower Middle Jurassic. In S. S. Buckman's chronology the ammonites of this lot date from the *Sausei* hemera of the Sonninian age to the *Epalxites* hemera of the Stepheoceratan age.

The Rico Aspen fauna is Jurassic and probably close in age to that from Silver lake."

Upper Volcanic Division. This division is thought to be represented on Hudson Bay mountain. The rocks are chiefly lava flows and thick, massive beds of coarse breccia. The rocks are mainly of andesitic composition, but rhyolite flows and perhaps intrusive bodies are also fairly plentiful. The structure of Hudson Bay mountain is complicated and the relationship between the upper volcanic division and the middle sedimentary division was not clearly established. It is likely, however, that the volcanic rocks overlie the sediments of the middle sedimentary division. The volcanic rocks are very similar to those of the upper division in Babine mountains and there the upper volcanic division overlies conformably the middle sedimentary division.[1]

The base of the division was not seen, but the part of the division exposed is between 2,000 and 3,000 feet thick. The strata differ lithologically from those of the lower volcanic division in that rhyolite and very coarse unstratified fragmental volcanic rocks are present.

Upper Sedimentary Division. Rocks of this division were seen only on the eastern flank of Hudson Bay mountain. They consist of arglilite and lesser amounts of quartzite, argillaceous quartzite, and conglomerate. Some of the strata in the middle part of the series as mapped are graphic and hold several seams of coal. The sediments are about 1,000 feet thick. The rocks appear to be just as hard as those of the middle sedimentary division. The sediments may include rocks of the Skeena formation, as coal has hitherto been found in central British Columbia only in the Skeena formation and in younger strata. The few fossils found were useless for age determination.

Structure. In the western part of the area the rocks of the lower volcanic division of the Hazelton group dip in general northeast at moderate to steep angles. In the northern part of this portion of the area the dips are more northerly and north of the area the rocks are probably overlain by sedimentary rocks of the middle sedimentary division. South of upper Zymoetz river the volcanic rocks dip gently east and are possibly overlain near Telkwa by the middle sedimentary division. On the western and northwestern sides of Hudson Bay mountain the lower volcanic division dips westward and may be overlain farther west by the middle sedimentary division. Two remnants of the middle sedimentary division are present on Hudson Bay mountain in overturned folds. The upper volcanic division on Hudson Bay mountain has a gentle, to steep, southeasterly dip. The upper sedimentary division dips eastward at moderate angles.

Faults are common on Hudson Bay mountain. A fault follows the valley of Silver creek and probably continues northward past the mouth of Trout creek and along Bulkley river for several miles. This is presumably a normal fault, along which the eastern side has subsided. The vertical displacement is probably more than 1,000 feet. The upper part of Zymoetz river may follow closely the outcrop of a northwesterly-trending normal fault which may continue northwestward across the low-lying area west of Pass creek toward Skeena crossing. A prominent overthrust fault, perhaps earlier than the normal faults, is present on Hudson Bay mountain, dipping gently southeastward. This fault can be seen from the mountain west of Hudson Bay mountain as an horizontal line which circles the north and west sides of the central part of Hudson Bay mounain. The elevation of the fault outcrop on the west side of Hudson Bay mountain is approximately 6,700 feet. This fault-plane if produced westward for half a mile would pass just above the overturned rocks above Silver lake and it is supposed that the thrust which occasioned the fault also caused the overturning to the west. The horizontal offset is not known, but is probably not less than 1,000 feet. Minor faults are common over the whole of the area. In the vicinity of Hudson Bay mountain these

[1]Op. cit.

faults strike mainly in two directions, northeast and northwest, and may have caused the rectangular pattern of the system of drainage observed there.

Correlation. The fossiliferous beds of the middle sedimentary division of the Hazelton group seen on Hudson Bay mountain can be correlated directly with those on Babine mountains and are of lower Middle Jurassic age.[1] Fossils collected by MacKenzie in 1915 from MacDonnell lake and from Grouse mountain near Telkwa are probably also of the same age. Fossil ammonites collected by Dawson in 1875 from Iltasyouco river were examined by Whiteaves and if correctly identified are also of lower Middle Jurassic age.

The Yakoun formation of Queen Charlotte islands appears to be very similar to the Hazelton group. The Yakoun was formerly considered to be Middle Jurassic and was correlated with the Tuxedin sandstone of Alaska.[2] More recently the Yakoun formation has been subdivided by McLearn[3] into four divisions similar to those of the Hazelton group.

Sedimentary rocks	Upper Jurassic
Coarse volcanic breccias	
Tuffaceous sediments	Lower Middle Jurassic
Fine-grained volcanic rocks	

Sediments of lower Middle Jurassic age are known also at lake Minnewanka in the Rocky mountains.[4]

It is apparent that the marine horizon represented by the middle sedimentary division is widespread. It is known in the Rocky mountains, in the interior of British Columbia, on Queen Charlotte islands, and from the interior of Alaska to Dean river, B.C.

Coast Range Batholith

Intrusive rocks of the Coast Range batholith are present in the southwestern part of the area. The most westerly areas of granitic rock are evidently tongues projecting eastward from the main body of the batholith. Isolated, stock-like bodies of granitic rocks are also present and presumably are of the same age. These rocks intrude the Hazelton group and older formations and are themselves cut by later dykes.

The larger stocks or tongues on Zymoetz river are granodiorite and granite. The stock at the head of Kleanza creek consists of a central part of granodiorite and an outer part about one-fourth mile wide of pink quartz porphyry, which grades inwardly into the granodiorite. The stock on Chimdemash creek is diorite and gabbro and that on Legate creek syenite and diorite.

Skeena Formation

The Skeena formation is present in Zymoetz River valley and on the low-lying area between Zymoetz and Kitsequekla rivers. The formation also occurs in the large neighbouring valleys. The Skeena has not been found above an elevation of 4,000 feet in this part of British Columbia.

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[1]Op. cit.
[2]MacKenzie, J. D.: Geol. Surv., Canada, Mem. 88, 1916.
[3]Personal communication.
[4]McLearn, F. H.: Geol. Surv., Canada, Sum. Rept. 1922.

The formation contains shale, argillite, coarse- and fine-grained sandstone, and a basal conglomerate. Several coal seams are present. In general the beds are folded into numerous open folds, the limbs of which in most instances dip 30 degrees, but locally as much as 70 degrees. Minor faults cut the formation.

The Skeena formation in the area rests unconformably on the Hazelton group. On Glacier creek it lies on the upper volcanic division of the Hazelton, whereas on Coal creek it rests on the lower volcanic division and perhaps in part on the middle sedimentary division. Dykes cutting the Skeena are rare.

It is becoming increasingly evident that the local areas of Skeena formation in central British Columbia are remnants of an extensive formation which was present in the valleys and which has been largely destroyed by Cretaceous and Tertiary erosion.

F. H. McLearn submits the following report on the marine fossils from the Skeena formation.

"Sediments at mouth of Coal creek west of Hudson Bay mountain, B.C.

Trigonia (at least two new species)
Belemnites sp.

This lot is of Cretaceous age."

Dykes and Sills

Lamprophyre dykes occur everywhere. Alaskite dykes and sills are as widely distributed, but are especially numerous in several places in the western part of the area and on Hudson Bay mountain. Granite, granodiorite, quartz porphyry, aplite, and many intermediate rock types are also present as dykes and sills.

The lamprophyre dykes are usually less than 4 feet wide and appear to be the youngest of the dykes. Some, at least, are younger than the Skeena formation. The granite, granodiorite, and alaskite dykes in some places are 100 feet wide, but usually have a width of about 20 feet. Finer-grained, acidic dykes are here referred to as alaskite, but many are of the composition of aplite. Local areas on Hudson Bay mountain and in other places in the western part of the map-area are ribboned with alaskite dykes. Most of the alaskite dykes and sills have quartz veins along both walls. A few alaskite dykes cut granitic stocks and were noted in this relation on Legate and Chimdemash creeks and on Zymoetz river.

The ages of the various classes of dykes are not known definitely. Some are younger than the Skeena formation, some may be older than this formation, but younger than the Coast Range batholith, and most of the dykes are probably of about the same age as the Coast Range batholith.

Pleistocene and Recent

Boulder clay is not common in the area, but is found locally on valley slopes. Glacial erratics occur sparingly. Recent deposits consist of silts, gravels, and sands in the stream valleys. Recent morainal matter occurs at the lower edges of the numerous glaciers.

ECONOMIC GEOLOGY

Historical

Gold placers were worked on a small scale as early as 1884 on Kleanza and Chimdemash creeks. Chimdemash creek was soon abandoned, but several later attempts were made to mine the gravels of Kleanza creek, although with very little success.

Mineral claims were staked in 1893 in Skeena valley and several years later on Telkwa river and on Hudson Bay mountain, and at about the same time coal was discovered in Telkwa valley. Numerous mineral properties have since been staked on Hudson Bay mountain, in Telkwa valley, and in the western part of the map-area. Coal has been shipped in small quantity for a number of years from deposits in Telkwa valley. Small shipments of silver, gold, copper, and lead ores have been made from many properties, but most of the production has come from the Henderson mineral claim on Hudson Bay mountain. J. F. Duthie operated this property for a few months in 1923 and shipped 297 tons which yielded approximately 0·20 ounce gold, 185 ounces silver, and 26 per cent lead per ton. The Federal Mining and Smelting Company operated the property for about a year in 1923-1924 and shipped 1,625 tons which yield approximately 0·20 ounce gold, 122 ounces silver, and 20 per cent lead per ton. J. F. Duthie again operated the property in 1925 and shipped 865 tons which yielded returns somewhat lower than, but comparable with, those listed above.

General Statement

The map-area contains a great number of groups of mineral claims staked on showings of diverse merits. On the whole the area is very well mineralized and it is rather surprising that so few properties have been developed into mines. The mineral veins, however, are narrow and only a few are so rich that ore as mined may be shipped with profit. Silver, gold, lead, copper, and zinc are the chief commercially valuable constituents of the veins. Some veins in the western part of the area appear to be large enough to furnish sufficient tonnage to warrant providing milling facilities, but very little development work has been done on them and they appear to be of low grade. Several replacement mineral deposits are present in the western part of the area, but these have not been developed sufficiently to afford any clear idea of their value. Several groups of claims were staked many years ago in the neighbourhood of Usk and are now held as Crown grants. No development work has been done on them for twenty years. These properties are close to the railway and as the cost of transportation is now much lower than it was when the properties were being developed, further work might disclose ore-bodies which could be mined with profit.

On Hudson Bay mountain the mineral showings are chiefly narrow veins containing galena, zinc blende, and lesser amounts of grey copper (tetrahedrite), pyrite, arsenopyrite, and chalcopyrite, and a small amount of quartz gangue. The veins carry silver. They occupy, in general, brecciated zones and locally consist of brecciated rock cemented by vein matter. Several veins contain mainly bornite and chalcopyrite. A few are quartz-arsenopyrite-zinc blende veins containing gold. A replacement deposit in a bed of limestone is also known, the mineralization being an intergrowth of pyrrhotite and zinc blende.

In the western part of the area galena-zinc blende veins are not so plentiful as on Hudson Bay mountain, but they do occur on Chimdemash and Legate creeks. Bornite veins with some chalcocite are fairly plentiful and in the vicinity of Usk contain coarse free gold, whereas those on Chimdemash and Kleanza creeks carry no free gold. Chalcopyrite with some bornite occurs in several replacement bodies in sheared and shattered rocks on Kleanza, Chimdemash, and St. Croix creeks. Quartz veins containing gold and sparingly mineralized with pyrite and chalcopyrite are numerous in the southwestern part of the area. Many of the numerous alaskite dykes in the western part of the area have quartz veins on one or both walls. Some of these veins contain galena and zinc blende and others, gold and pyrite.

On Hudson Bay mountain several veins are parallel and apparently form a single vein system. This condition was noted also in the western part of the district where in several places three to six parallel veins lie from 100 to 300 feet apart.

Scheelite and molybdenite occur in the southwestern corner of the area. The scheelite occurs, with free gold, in a quartz vein 1½ feet wide, and is not evenly distributed, but is present in irregular, sporadic lumps. The molybdenite is in a pegmatitic phase of granite and occurs in what appears to be an oval area perhaps 100 feet by 200 feet.

Another type of ore deposit may be present in the southwestern part of the area. This is the contact metamorphic type occurring as a replacement of limestone and usually carrying chalcopyrite, magnetite, garnet, epidote, tremolite, quartz, and calcite.

Some evidence was obtained relating to the origin of the ore deposits. The belief has been expressed that many of the mineral deposits of Babine mountains are related to local igneous bodies and not to the Coast Range batholith[1]. A similar condition seems to prevail on Hudson Bay mountain. In the western part of the map-area no regular grouping or distribution of mineral deposits was noted around any of the numerous stocks of granodiorite. On the other hand, the distribution of the different types of mineral deposits exhibits a well-defined, gradual change in their character from place to place along one general line of direction. The gradation ranges from high temperature scheelite, molybdenite, and gold deposits, through copper deposits, to lower temperature silver, lead, and zinc deposits. The higher temperature deposits lie in the Coast Range batholith and the lower temperature types, 15 miles from its edge. The evidence favours the idea that one source, the Coast Range batholith, gave rise to all these mineral deposits.

DESCRIPTION OF MINERAL DEPOSITS

The geology and ore deposits of Hudson Bay mountain are the subject of a report by Mr. Jones and the mineral deposits of the mountain will not be described here. Most of the mineral deposits in the western part of the area were visited by the writer and a brief description of these follows.

[1]Op. cit.

More detailed descriptions are given in reports of the Minister of Mines, British Columbia, and any assays listed below unless otherwise stated are taken from those reports.

Properties on Legate Creek

Several groups of mineral claims have been staked on Legate creek near its head, either in or close to a stock of diorite.

Frisco Group. (Owner, M. Orr.) Located on the south side of Frisco creek at an elevation of approximately 4,800 feet. Development consists of two short adits and several open-cuts. The country rock is andesite, of the Hazelton group, which appears to strike south-southeast and dip gently eastward and is cut by a 100-foot sill of quartz porphyry. A bed of greenish andesite or tuff about 40 feet thick and lying above the sill contains sparse disseminations and thin seams of copper minerals, chiefly chalcopyrite. The best mineral showing is from 1 to 2 feet wide and consists of chalcopyrite, quartz, and bornite. This vein-like deposit is apparently a seam between beds of volcanic rock. The showing is located on a precipitous mountain slope and was seen for a length of 100 feet, but may extend farther. Hand-sorted ore consisting chiefly of bornite assays 42·2 per cent copper, 35·5 ounces silver, trace gold.

M. and K. Group. (Owners, M. Orr and partners.) Development consists of short adits and numerous open-cuts. Two mineral showings are located at elevations of 3,500 and 4,700 feet on the north side of the East fork of Legate creek. The country rock is andesite and breccia, striking northeast and dipping 30 degrees southeastward, and an intrusive stock of diorite, the contact of which passes between the two showings. The lower showing, discovered recently, is a quartz vein in diorite and strikes north-northeast and dips 50 degrees westward. The vein has been traced for 100 feet, is 1½ feet wide, and consists of quartz, chalcopyrite, galena, and perhaps some grey copper. The hanging-wall has been bleached to a light-coloured rock for a distance of 3 feet and the bleached part contains quartz stringers and disseminations of pyrite and chalcopyrite.

The upper showings consist of one or more sulphide veins which lie parallel to the dip and strike of the rocks and which coincide approximately with the slope of the hill-side. Several veins appear to be present, exposed for a distance of 500 feet up and down the hill-side and entering the ground at a slight angle. There may be, however, only one vein folded or faulted so as to outcrop in several places. The vein or veins are 6 inches to 4 feet wide and contain brecciated rock, quartz, chalcopyrite, galena, bornite, grey copper, specularite, and copper carbonates. Locally, the narrower parts of the veins consist of solid sulphide which is an intergrowth of galena and bornite with only minor amounts of the other minerals. The wider parts usually contain more chalcopyrite, country rock, and quartz. Several shipments of ore have been made from the upper showings. One shipment of 120 tons contained 20 per cent copper, 25 per cent lead, and 25 ounces silver per ton. This was all from float ore. It is evident that the float was derived from a vein exposed along the southeastern side of the area of float. The hill-side is covered with drift, so that veins can be traced only by open-cuts and trenches. The property appears to have merit and is decidedly worth careful examination by mining companies.

M. and M. Group. (Owner, R. Moore.) The showings are located at an elevation of 4,600 feet on the south side of the East fork of Legate creek. Development consists of open-cuts. The country rock is diorite cut by a 200-foot quartz porphyry dyke. Three veins are exposed, striking northwestward and dipping 45 to 70 degrees southward. The two smaller veins are each about 4 feet wide and contain quartz crystals, calcite, galena, grey copper, sphalerite, chalcopyrite, and, rarely, native silver. The larger showing is a mineralized shear-zone which splits into two diverging zones near the top of the mountain. Where the two zones merge the mineralization extends over a width of 20 feet. This showing is sparingly mineralized with galena, grey copper, sphalerite, pyrite, and chalcopyrite. The showing consists chiefly of brecciated, sheared, and bleached diorite ribboned with quartz and calcite veinlets which are individually up to 2 feet in width. The veins have been traced over 1,000 feet and strike northwestward down a steep hill-side, the slope of which is 46 degrees. In general the mineralization is very scant. Assays across one foot of well-mineralized vein matter show from 0·02 to 0·26 ounce gold, and from 25 to 200 ounces silver. The property is well situated for cheap mining.

White Bear and South Fork Claims. (Owners, W. L. Jordan and J. R. Smith.) Development consists of open-cuts. The claims are located at an elevation of 4,200 feet on the South fork of Legate creek. The country rock is volcanic breccia intruded by diorite and cut by aplite and lamprophyre dykes. The showing is a quartz vein occupying a fault zone in breccia and lying parallel to an aplite dyke which is cut by stringers from the vein. The vein is exposed on both sides of a glacier half a mile wide. The showing strikes west-northwest and is from 2 to 10 feet wide. In some places parallel quartz stringers on both sides of the main vein make up a zone 30 feet wide, which consists of 60 per cent rock and 40 per cent quartz. Locally the quartz contains scheelite. This mineral has not been previously noted in the vein and the percentage of scheelite has not been determined. However, in any further development of the vein scheelite should be searched for. Sulphides are sparingly distributed through the quartz, but are abundant in a few, small, well-mineralized shoots. One of these was 20 feet long by 2½ feet wide and contained at least 35 per cent sulphide by volume. The sulphides were galena, sphalerite, bornite, grey copper, chalcopyrite, and perhaps others. Native silver was seen, but was rare.

Regina Group. (Owners, J. Brown and partners.) The following description of the property is taken from the notes of Mr. Jones. The property is located at an elevation of 4,900 feet south of the South fork of Legate creek. The country rock is breccia intruded by diorite. A crosscut tunnel has been driven under a showing on the surface, but not far enough to reach the vein. The vein lies partly in breccia, but mostly in diorite, strikes southeastward, and dips steeply southwestward and consists of quartz stringers in a shear-zone 6 feet wide. The quartz is mineralized with pyrite, chalcopyrite, galena, grey copper, and chalcocite, and although rich specimens can be obtained the quartz is in general very sparingly mineralized. The vein has been traced for 700 feet or more. A sample across 1½ feet of vein matter assayed 0·02 ounce gold and 71 ounces silver.

Properties on Chimdemash Creek

Several mineral groups are located in Silver basin at the head of Chimdemash creek. Most of the veins are in volcanic rocks near a stock of diorite and some are in the diorite. The veins are recent discoveries and are developed so far by a few open-cuts only. Two series of veins are present, one striking northeastward and the other southeastward. One open-cut on the Silver Basin group is on the intersection of two veins and this is the best showing of that group. The veins found so far are small, but contain high-grade silver ore and the basin warrants careful prospecting.

Silver Basin and Silver Crown Groups. (Owners, J. D. Wells and partner.) The showings consist of quartz veins in volcanic rocks. The veins are from 4 inches to 4 feet wide and have been traced for half a mile. It is not certain that individual veins have been traced so far, but veins striking northeastward have been exposed at intervals for this distance. A vein on the Silver Basin group is 3½ feet wide and contains galena, grey copper, chalcopyrite, and some native silver. This vein is crossed by a narrow vein with similar mineralization. On the Silver Crown group several veins from 4 inches to 2 feet wide strike southeastward and contain bornite, chalcocite, galena, and grey copper. The veins are offset by a number of small faults. Four assays are quoted below.

Silver Basin vein across 10 inches,	0·02 oz. gold,	161·6 ozs. silver		
Silver Basin vein across 6 inches,	0·01 oz. gold,	54·2 ozs. silver,	26·6 per cent copper
Silver Crown vein across 4 inches,	0·04 oz. gold,	142·0 ozs. silver,	5·6 per cent copper
Silver Crown vein across 20 inches,	trace gold,	14·3 ozs. silver,	2·7 per cent copper

Coffee Pot Group. (Owners, A. Stewart and partners.) The property is located in the northern part of Silver basin. Six or more small southeasterly striking veins have been exposed, and consist of quartz, galena, and grey copper. One vein consists almost entirely of bornite. One vein is 3 feet wide, but the others are less than one foot wide. These veins all lie in volcanic rocks. Another vein several feet wide lies in diorite and is very sparingly mineralized.

Banner Homestake Group. (Owner, L. E. Moody.) The property was examined by Mr. Ramsell, from whose notes the following description is taken. The property is located at an elevation of 4,200 feet on the south side of Chimdemash creek about 11 miles from Usk. The country rock consists of volcanic breccias and lava flows cut by green dykes. The ore showing has been developed by two open-cuts and is a brecciated and sheared zone 20 feet or less in width, which has been traced for 1,000 feet. A green dyke 3 feet wide lies in the mineral zone. The zone is mineralized with chalcopyrite and a little bornite and is much stained with copper carbonates. The chief value lies in copper. No assays across the zone have been obtained, but the whole is probably low grade.

Properties on Kleanza Creek

A number of mineral groups have been staked on Kleanza creek in and near stocks of granodiorite. These are essentially copper properties. Gold and silver are not present in valuable quantity. The showings are from 12 to 22 miles from the railway.

21854—8½

North Star Group (formerly *Avon Group*). The property is near the head of Kleanza creek. The workings, consisting of open-cuts and a short adit, expose garnetite slightly mineralized with chalcopyrite, bornite, and magnetite. Beds of limestone associated with andesite are here intruded by a stock of granodiorite and the mineral deposits appear to lie near the contact of the intrusive. The mineral deposit is below timber-line and is not easy to trace on the surface. It probably occurs, however, as a replacement of limestone and further development should be directed toward tracing and prospecting the limestone.

Peerless Group. (Owners, O. T. Lindland and partners.) The property is located near the head of Kleanza creek, 4,500 feet above sea-level. A sheared zone striking southwestward and several feet wide crosses volcanic rocks and is offset by northwesterly striking faults. The zone contains quartz-calcite veinlets up to one foot in width which are mineralized with a mixture of chalcocite, bornite, magnetite, and chalcopyrite. Garnet, epidote, hornblende, tremolite, and jasper are present, but chiefly in the wall-rocks. The zone is said to extend for over a mile along the surface. The following assay is quoted by W. J. Elmendorff in a private report on the property.

Average sample across a width of 4 feet.

0·04 oz. gold, 4·6 ozs. silver, 11·93 per cent copper

Wells Group. (Owners, J. D. Wells and partners.) Situated above timber-line on the Zymoetz River side of the divide at the head of Kleanza creek. These mineral deposits lie in volcanic rocks and are replacements along shattered faults. On the Irene and Giant Powder claims a mineral zone striking east-southeast is 3 to 5 feet wide and contains stringers of quartz and calcite mineralized with bornite and chalcocite. On the Wells claim a parallel zone over 6 feet wide contains stringers of quartz and calcite mineralized with chalcocite and cuprite. Some of the stringers are 6 inches wide and are half sulphide by volume. An assay across 4 feet on this showing returned: trace gold, 2·3 ounces silver, 9·5 per cent copper.

Montana Group. (Owners, J. D. Wells and partners.) Situated north of the Wells group on the Zymoetz River slope at an elevation of 4,500 feet. The ore-zone is 6 to 8 feet wide for 400 feet and is said to be traceable for 1,500 feet. It is a shear-zone partly replaced by copper minerals. The strike is eastward and the dip vertical. The outcrop is heavily stained with copper carbonates.

Lucky Jim Group. (Owner, Fred Forrest.) Development consists of adits and large open-cuts. The property is situated below 2,000 feet on the north side of Kleanza creek about 13 miles from Usk. The country rock is andesite, tuff, and breccia, apparently striking northwestward and dipping gently northeastward. The main showing is a band of volcanic rock containing disseminations and small gash veinlets of bornite and chalcopyrite. This zone strikes northwestward and may be a mineralized bed of rock. This is joined from the north by a southerly striking and steeply dipping vein. The vein is mineralized with bornite and chalcopyrite and at the junction some very good ore is found. The development has been confined to the vein and its junction with the northwesterly striking zone. The following assays have been obtained.

Across 7 feet, trace gold, 2·7 ozs. silver, 6·3 per cent copper
Across 5 feet, trace gold, 4·6 ozs. silver, 6·9 per cent copper
Across 5 feet, 0·04 oz. gold, 2·7 ozs. silver, 5·4 per cent copper
Across 5½ feet, trace gold, trace silver, 3·5 per cent copper

Properties on Zymoetz River

The following descriptions are taken from Mr. Jones' notes.

Brunsing's Property. Located at an elevation of 1,000 feet on the south side of Zymoetz river 2 miles from its mouth. A shear-zone in diorite contains numerous quartz stringers sparsely mineralized with pyrite, pyrrhotite, and chalcopyrite. At another place a quartz vein is exposed 16 inches or less in width and lying practically horizontal. The vein is sparsely mineralized with chalcopyrite. The chief value lies in gold.

Dardanelle Group. (Owners, Messrs. McNeil and Carmichael.) The property is situated in granodiorite at an elevation of 1,400 feet on the north side of Zymoetz river 14 miles from its mouth. Two quartz veins striking east-northeast and dipping steeply northwestward lie on either side of an aplitic dyke 20 feet wide. The top vein is 4 feet wide and the bottom one 2½ feet, and both have been traced for 600 feet. The quartz veins have been sheared slightly and seams of pyrite, copper minerals, and galena occur along the shear planes. A sample across 4 feet on the upper vein contained 0·22 ounce gold per ton. Other narrower quartz veins on the property are reported to contain a greater proportion of gold.

Properties in the Vicinity of Usk

A number of mineral claims have been staked near the railway in Skeena valley, well below timber-line and consequently excellently situated with regard to transportation and timber. Some of these are old Crown-granted properties on which nothing has been done for many years. In practically all of the properties the chief value lies in gold; some are valuable because of their copper content.

Cordillera Group. (Owners, Kitsalas Mountain Copper Company.) Development consists of 1,500 feet of adits and winzes. Situated one mile from Usk on the west side of Skeena river and only a few hundred yards from the railway. The country rock consists of hard and soft green rocks striking northeastward and dipping northwestward. This has been intruded by a number of dykes. The softer rocks are chlorite schists and the harder strata are perhaps tuffaceous quartzite. Four veins are exposed on the surface above two long crosscut adits. The three lower veins are parallel and almost equally spaced, the uppermost being 500 feet above the lowest one. The strike is northeastward and the dip northwestward. No. 1 vein, the lowest of the four, is 4 feet wide and dips 25 to 45 degrees. It has been developed by three short adits and has been traced along the strike for 500 feet. It lies in a band of green schist between two thick bands of hard rock, and apparently occupies a fault confined to the softer bed of rock. Numerous short veins diverge from the main vein. Veins

Nos. 2 and 3 are from 1 to 2 feet wide. No. 4 vein is 3 to 6 feet wide and outcrops about 200 feet above No. 3 vein. A sample across 3 feet on No. 1 vein assayed 0·40 ounce gold, 3·8 ounces silver, and 7·1 per cent copper per ton. The vein matter is quartz sporadically mineralized with bornite, chalcocite, and coarse free gold.

In developing the property a crosscut adit was started 150 feet below No. 1 vein. This adit intersects two veins, Nos. 1 and 2 "blind" veins, so-called because they did not outcrop. A thick mantle of drift covers the solid rock. A large, gently dipping quartz vein was encountered near the face of the adit and this was considered to be No. 1 vein. It is not likely, however, that No. 1 vein has been reached. Another crosscut adit 80 feet lower was driven and this crosses the two blind veins. These two veins are vertical and strike northeastward. No. 1 blind vein is small, but No. 2 blind vein varies from 1 to 11 feet in width. It is commonly 3 feet wide and in some places is very well mineralized with bornite, chalcocite, and free gold. Some of the showings on this group are good and warrant further development.

Lucky Luke Group. (Owners, L. E. Moody and R. Lowrie.) Situated on the west side of Skeena river 1¼ miles from Usk and a few hundred yards from the railway. The ore-body has been developed by two drift adits one 60 feet above the other, by raises from both adits, by a winze from the upper adit, and by a sub-level drift between the two adits. The country rock consists of greenish and greyish schists cut by acidic dykes. The vein occupies a fault or shear-zone striking west-northwest and dipping 70 degrees northward. An aplite dyke earlier than the fault occupied by the vein is exposed for a short distance along the hanging-wall of the vein. It is likely that the north side of the ore-zone fault moved eastward and upward in relation to the south side. Later faults striking northeastward offset the vein and in all instances noted the northwesterly side has moved southwestward along these faults. At the face of the lower adit the vein is faulted off and the westward extension of the vein can probably be found to the southwest. The vein is in general from 1 to 3 feet wide and consists of quartz mineralized with bornite, chalcopyrite, pyrite, and gold. It contains good shipping ore, is very close to the railway, and will be easy to operate unless many faults are encountered. A shipment of 26 tons of ore in 1924 returned 0·73 ounce gold, 12·7 ounces silver, and 22·44 per cent copper per ton. This was from an ore-shoot which required very little sorting. The westward continuation of the vein should be searched and the ground should be prospected for other parallel veins which may be present.

Emma, Four Aces, and Usk Groups. Situated on the east side of Skeena river ½ to 2 miles east of Usk. Development consists of short adits and open-cuts. The country rock appears to be altered tuffs and flows of the Hazelton group.

The Emma group was staked in 1893, was Crown-granted in 1898, and since that time no work has been done on the property. The lowest workings consist of a drift adit driven on a quartz vein 1 to 6 feet wide and mineralized with chalcopyrite, bornite, and pyrite. The strike is eastward and the dip 50 degrees north. An average sample assayed 0·3 ounce gold, 1·9 ounces silver, and 3·3 per cent copper. Another quartz vein higher up and approximately 750 feet above sea-level is 6 feet wide. It strikes east-southeast and dips 60 degrees northward. Two feet along the hanging-wall side of this vein is very well mineralized with bornite and chalcopyrite. At an elevation of 1,000 feet another vein is exposed 15 feet wide, consisting of quartz very sparingly mineralized with sulphides. These vein exposures line up in an east-southeast direction and they may be parts of a single vein. Another parallel quartz vein 150 feet northeast and over 3 feet wide is mineralized with bornite.

On the Usk group the mineral deposit is not well exposed. It is parallel to the Emma vein a short distance northeast, is 3 feet wide, and contains bornite and other sulphides. The vein cuts a bed of calcareous rock which is itself mineralized with bornite.

On the Four Aces group, east of the Usk group and about 500 feet higher, is a flat-lying quartz vein 10 feet thick very sparingly mineralized with pyrite, chalcopyrite, and galena.

The veins, especially those on the Emma group, are very well-defined and give promise of continuity. It is possible that development would expose good-sized bodies of milling ore.

Golden Crown Group and Properties of Kleanza Company. These properties adjoin and are located from 600 to 4,000 feet above sea-level on the east side of Skeena river 3 miles below Usk and about one mile from the railway. Development consists of several adits and open-cuts. The country rock is granodiorite containing numerous large inclusions of schistose rocks and cut by lamprophyre dykes.

The vein in the Golden Crown group consists of quartz sparingly mineralized with pyrite, chalcopyrite, and perhaps arsenopyrite. The main value lies in gold. The vein strikes southeastward, dips 30 to 40 degrees northeastward, and averages 3 feet in width.

The properties of the Kleanza Company lie south of the Golden Crown and higher up the mountain. Six parallel veins 150 feet apart are present, striking south-southeast and dipping 60 degrees northeastward. No. 1 vein is 3 feet wide, No. 2 is 6 feet wide, Nos. 3, 4, and 5 are 1 to 3 feet wide, and No. 6 is 3 feet wide. All of the veins are gold-bearing quartz veins containing a little pyrite and chalcopyrite. No. 5 vein contains galena as well and from 5 to 20 ounces of silver per ton.

The veins on the Golden Crown group and on the properties of the Kleanza Company are readily accessible. It is not likely that much shipping ore will be obtained, but it is probable that a moderate tonnage of good milling ore can be developed. Faults offsetting the veins are present. In two examples of those striking east the south side has subsided. One northerly striking fault was noted and it was later than the easterly striking faults.

Properties on Thornhill Mountain

Several groups of mineral claims are situated on Thornhill mountain in a country rock of granodiorite. This mountain is the northwestern part of the ridge which lies south of Zymoetz river. The country rock is chiefly granodiorite, but quartz porphyry and granite phases are present. The granitic rocks hold large inclusions of schistose rocks and are intruded by aplite dykes. Only a few of the mineral deposits were visited.

A sheared zone, perhaps 20 feet wide, on the Ptarmigan group, contains stringers and disseminations of galena, grey copper, chalcopyrite, and pyrite, chiefly over a width of 8 feet. This zone strikes east-northeast and has not been developed beyond one open-cut. Several hundred feet below this showing on its line of strike a quartz vein is exposed striking north-northeast and containing a foot of vein matter well mineralized with grey copper and galena. Parallel to the shear-zone and about 200 feet north of it is another showing. This is 75 feet wide and consists of rock ribboned with quartz veinlets. It has the appearance of a shear-zone holding quartz veinlets in the shear planes. The whole zone consists approximately of 40 per cent quartz sparingly mineralized with chalcopyrite and pyrite and 60 per cent rock matter.

On the St. Paul claim of the Ptarmigan group an aplite dyke 15 feet wide has quartz veins along both walls. The dyke and veins strike southwesterly on the St. Paul claim, continue westward through the Society Girl group, and northwestward into the Sadie claim of the Ptarmigan group. The dip is 40 to 60 degrees north. The dyke and vein have been traced for over half a mile. Along the eastern part of the dyke the better vein is on the foot-wall, is 2 to 3 feet wide, and mineralized with pyrite, chalcopyrite, galena, sphalerite, and free gold. On the Society Girl group the hanging-wall vein is the better and is similar in size and mineralization to the foot-wall vein farther east. A northeasterly striking fault near the Sadie-Society Girl boundary offsets the northwestern side 150 yards northeastward.

Another quartz vein 6 inches to 2 feet wide on the Ptarmigan group has been traced for 200 feet. This is a pegmatitic quartz vein mineralized with pyrite, chalcopyrite, galena, sphalerite, free gold, and scheelite, in a gangue of quartz, barite, and feldspar. The scheelite is sporadically distributed through the vein in fairly large nodules as much as 3 inches in diameter and makes exceptionally fine specimens.

Michaud Brothers, who own the Ptarmigan group, have staked a showing of molybdenite one mile south of the scheelite vein. The country rock is grey granite of rather fine grain. An oval area perhaps 100 by 200 feet is spotted with rusty patches and contains as well several pegmatite dykes about 1 foot wide by 20 feet long. The rusty patches are the oxidized outer parts of nodular areas of coarsely crystallized minerals, the outer part of which contains a little pyrite. Inside of the rusty border is muscovite, yellow mica, crystals which may have been tourmaline, but which now consist of muscovite, radial aggregates of clinozoisite, quartz crystals, and nodules of molybdenite. The rusty areas are 6 inches to several feet in diameter. The nodules of molybdenite are 1 to 2 inches in diameter, are radially laminated, and in many places coalesce to form larger, irregular masses of the mineral. Oxidation of the molybdenite has yielded small quantities of molybdenite.

Properties in the Vicinity of Terrace

Autumn Group. (Owner, S. Alger.) Situated on the west side of Skeena river, 10 miles below Terrace and only a few hundred yards from the railway. A quartz-epidote zone 20 feet wide, mineralized with pyrite and a little chalcopyrite, has been traced for 2,000 feet. This is apparently a replacement of a bed of limestone. The rocks now are sill-like bodies of granodiorite, green schists, marble, and quartz-epidote zones. The quartz-epidote zone parallels Skeena river. The places exposed by workings are too sparingly mineralized to be ore, but other parts of the zone may contain shoots of chalcopyrite. A parallel zone higher up the mountain contains a good deal of magnetite and a fair proportion of chalcopyrite. These mineral zones are close to the railway and are large enough for large-scale mining. Prospecting should be confined to tracing the mineral zones and exposing them at intervals in search of chalcopyrite ore. It is the opinion of the writer that good-sized bodies of milling ore may be discovered in this vicinity.

COAL

Several coal seams have been mined on Telkwa river, on a small scale, for a number of years. The seams lie in the rocks of the Skeena formation. This formation is exposed on Hudson Bay mountain at Glacier, Pass, and Trout creeks, and in one or two other places where the area was too small to show on the geological map. The formation is also probably present on Kitnayakwa river. A larger area of the formation is exposed at Coal creek and this is the only known place in Zymoetz River area where the formation holds coal seams over 3 feet in thickness. This coal area is over 30 miles from the railway and consequently may not be mined for some time.

Coal is also present in what appears to be an older formation on Hudson Bay mountain. This is located one mile west of the railway at lake Kathlyn and is the property of the Lake Kathlyn Coal Company. The coal seams lie in argillites, quartzites, and graphitic argillites which appear to be part of the upper sedimentary division of the Hazelton group, and which is perhaps of Upper Jurassic age. As was stated earlier in this report the age of the coal-bearing rocks here is not established. Rocks of the Skeena formation may overlie the upper sedimentary division of the Hazelton group at this place and the coal seams may really lie in the Skeena formation. The coal seams dip 40 to 70 degrees east and contain numerous graphitic, slickensided fractures. Six seams are known, three of which are over 3 feet thick. Proximate analyses of the coal have been obtained, but do not furnish a good basis for classification. In the analyses moisture averages 13 per cent, volatile matter 8 per cent, fixed carbon 63 per cent, and ash 16 per cent. It will be noted that the percentage of volatile matter is rather low for a fuel-burning coal and that of moisture and ash is too high for a desirable fuel. The specific gravity of selected pieces is 1·60 which is rather high. A thorough test of the burning qualities of the coal should be made, as, judging from appearance, specific gravity, and proximate analyses, the coal is of doubtful value as a fuel.

GEOLOGY AND ORE DEPOSITS OF HUDSON BAY MOUNTAIN, COAST DISTRICT, B.C.

By R. H. B. Jones

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INTRODUCTION

Hudson Bay mountain is situated west of Smithers on the Canadian National railway, about 230 miles east of Prince Rupert. The mountain is an isolated mass rising to nearly 9,000 feet and surrounded by valleys whose floors lie at elevations of 1,800 feet to 2,900 feet. It has a width of 10 miles and a length of 20 miles, the longer axis trending northwest, paralleling Bulkley valley on the east. The mineral deposits of the mountain have attracted attention for many years. The Canadian National railway skirts the eastern foot of the mountain, giving good shipping facilities. A motor road about 15 miles long, from Smithers to the Henderson mine, furnishes easy access to the western slope of the mountain. Trails from Smithers, lakes Kathlyn and Evelyn, lead to various properties on the eastern side of the mountain.

The following report[1] and accompanying map (Figure 9) are based on geological field work carried on during the summer of 1925 when the writer, under the direction of Mr. George Hanson, made a study of the geology of the mountain and examined many of the mining properties and prospects located on it. A topographic map prepared by W. W. Leach in 1909 was used as a base for geological mapping.

The writer is indebted to the mining men and prospectors of the district for information and other courtesies, especially to Mr. J. R. Turner, Supt. of Duthie Mines, Limited, Mr. Aldrich, Mr. Donald Simpson, Mr. Schufer, and Mr. Garde. The writer wishes to express his thanks to Mr. George Hanson for his advice and assistance and to the members of the Department of Geology, University of Wisconsin, for advice and helpful criticism.

[1]The report, substantially in its present form, was submitted as a partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Wisconsin, in June, 1926.

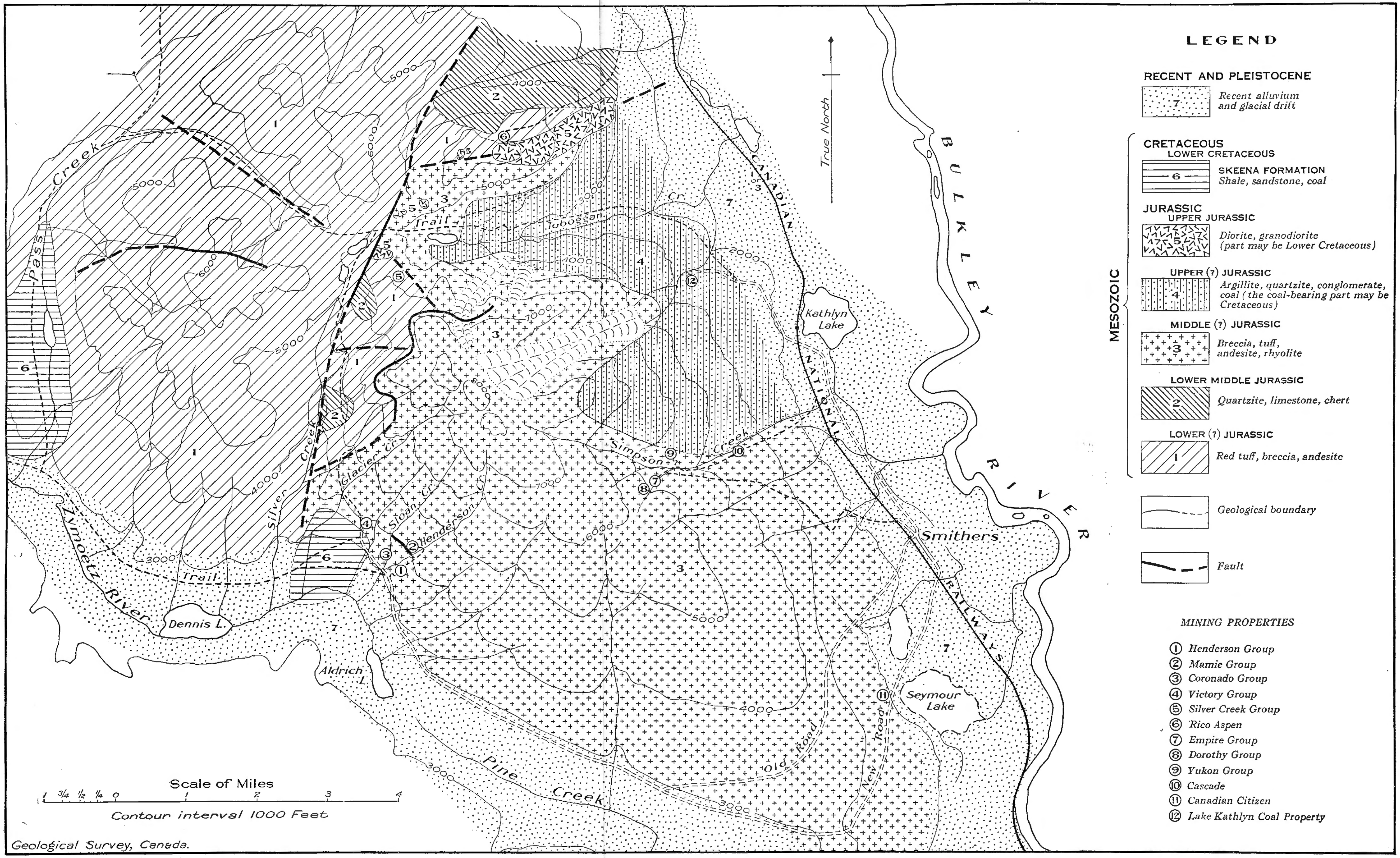

FIGURE 9. Geology of Hudson Bay mountain, Coast district, B.C.

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GENERAL GEOLOGY

The district is near the boundary of the two physiographic provinces known as the Coast Range system and the Interior Plateau, the eastern edge of the Coast range lying about 25 miles southwest of Smithers. The country is characterized by isolated groups of mountains separated by comparatively wide valleys with low divides. Hudson Bay mountain and the Rocher Déboulé group to the north have a rugged topography, but some of the mountain masses have a subdued relief. The unnamed mountain southwest of Hudson Bay mountain gives the impression of a dissected plateau with an upland surface at about 5,500 feet elevation.

Hudson Bay mountain forms a watershed between Bulkley river on the east and the headwaters of Zymoetz river on the west. Bulkley river occupies a broad, northerly trending valley separating Hudson Bay mountain from Babine mountains to the east. Westward, the valleys form a general pattern which may be resolved into two systems trending north-northwest and east-northeast. The same relations hold over a large area.[1] The mountain is divided into three major parts by the valleys of Toboggan, Pass, and Silver creeks which rise in a basin-like pass at about 5,100 feet elevation. The summits of the northerly and northwesterly segments rise to nearly 7,000 feet and are easily accessible. The peaks of the southern segment exceed 8,300 feet in elevation and are sharp and precipitous. They have on the north and east sides alpine glaciers which have produced a rugged topography characterized by sharp peaks and narrow, craggy ridges.

Hudson Bay mountain lies about 25 miles northeast of the eastern contact of the Coast Range batholith and within the limits of a broad belt largely underlain by Jurassic strata of the Hazelton series. The mountain mass is part of what has been termed the Zymoetz River area. An account of the geology of this area is given in the preceding report by George Hanson and, therefore, in this report attention need be directed only to certain geological details exhibited on Hudson Bay mountain.

[1] Malloch, G. S.: "Reconnaissance on the Upper Skeena River between Hazelton and the Groundhog Coal Field, B.C."; Geol. Surv., Canada, Sum. Rept. 1911, p. 71.

Table of Formations

Period	Formation	Lithology
Recent and Pleistocene.......	....	Recent alluvium and glacial till
Lower Cretaceous............	Skeena formation...........	Conglomerate, sandstone, shale, coal
Upper Jurassic to post-Lower Cretaceous	....	Dyke rocks
Upper Jurassic (?)............	Coast Range batholith......	Granodiorite, diorite, etc.
Upper (?) Jurassic...........	....	Upper sedimentary division
		Upper volcanic division
Lower Middle Jurassic.......	Hazelton group.............	Middle sedimentary division
Lower (?) Jurassic...........	....	Lower volcanic division

DESCRIPTION OF FORMATIONS

Hazelton Group

Lower Volcanic Division. Rocks of the Lower Volcanic division are best exposed southeast of Silver lakes near the Silver Creek group of mineral claims. The division consists chiefly of andesitic flows, limestone, and fragmental rocks. Tuffs and breccias predominate. The lowest rocks exposed consist of purple and green andesitic flows, amygdaloidal in part. These are hornblende feldspar porphyries with felsitic structure. The fine-grained groundmass has been greatly altered and replaced by calcite accompanied by chlorite. A large amount of the hornblende has altered to epidote. The purple and reddish colours are due to the presence of hematite scattered through the matrix.

A bed of fossiliferous limestone about 60 feet thick overlies the flows. It is intensely anamorphosed and recrystallization has made the identification of fossils doubtful. A collection of fossils from this horizon has been examined by F. H. McLearn who reports that the fossils may be of Jurassic age.[1] The limestone grades into a green, calcareous tuff, which in turn grades into a less calcareous purple tuff; both phases contain abundant chlorite. Overlying these tuffs is a series of bedded and banded tuffs, breccias, and cherts, purplish to red in colour, probably in excess of 800 feet in thickness. This division at its summit grades into the conformably overlying Lower Sedimentary division.

The exposure near the Silver Creek group of claims is part of an overturned syncline plunging west-northwest. The series is cut off at an elevation of about 6,400 feet by an overthrust fault.

Exposures west of Silver lakes consist of flows, tuffs, and breccias, probably in excess of 5,000 feet in thickness. The strata in general strike northeast and dip northwest at 45 degrees. Pass creek separates these rocks from those north of Silver lakes, which strike northwest,

[1]Geol. Surv., Canada, Sum. Rept. 1924, pt. A, p. 25.

the dip varying from 36 degrees to 70 degrees southwest. This dissimilarity in attitude to the northeast and southwest of Pass creek suggests the presence of a fault along Pass creek.

Middle Sedimentary Division. Rocks of the Middle Sedimentary division overlie the Lower Volcanic division southeast of Silver lakes. Sediments outcropping north of the Rico Aspen mining property are correlated with the Middle Sedimentary division on lithological similarity, degree of anamorphism, and palæontological evidence.

The division consists of a well-bedded series of limestones and indurated sandstone with cherty and fissile, shaly bands. The limestone beds which are highly fossiliferous seldom exceed a foot or two in thickness. At the base of the division the underlying volcanics consist of a purple breccia grading upwards into a greenish grey tuff. The tuff grades upwards into tuffaceous limestone and this, in turn, into a highly fossiliferous limestone in a bed 6 inches thick. Above this fossiliferous limestone is a series of well-cemented sandstones, possibly tuffaceous rocks, zones of limy rock and limestone, shaly fissile bands, and cherty rocks. In the upper part of the series bands of chert are numerous. The fossils as determined by F. H. McLearn[1] indicate a lower Middle Jurassic age.

The strata of the division southwest of Silver lakes form an overturned syncline plunging to the northwest. The sediments extend up to an elevation of 6,100 feet. At an elevation of about 6,400 feet, a thrust fault is traceable along the face of the mountain for nearly 3 miles. Movement along the thrust fault was from the southwest to the northeast and dragged and overturned the underlying rocks. To the west a fault cuts off the sediments and red volcanic rocks outcrop. This fault parallels Silver creek and continues to the north-northeast on the east side of Silver lakes.

Upper Volcanic Division. Rocks of the Upper Volcanic division outcrop over the greater part of the area and underlie nearly all the southern slope of the mountain. They consist of flows, breccias, tuffs, and agglomerates, ranging in composition from andesite to dacite and rhyolite. The flows are porphyritic and many show flow structure which varies widely in attitude and is, therefore, of little or no value as a criterion for the interpretation of structure. The massive and fragmental members of the series appear to grade into one another, either due to an original condition, or, if contacts formerly were sharp, because they have been obscured by anamorphism which has chloritized and silicified the rocks. All types show alteration to a greater or less degree. The porphyrites vary in colour, the least altered being purplish to greenish. They are medium-grained with plagioclase (oligoclase-andesine) and orthoclase phenocrysts. The green colour is due to the development of chlorite. The more acidic phases such as dacite and rhyolite are more abundant towards the top of the division. It is noteworthy that the rocks of the Lower Volcanic division are characterized by ferromagnesian minerals, chiefly hornblende, whereas the flows of the Upper Volcanic division are dominantly feldspar porphyries and related types.

Upper Sedimentary Division. Rocks of the Upper Sedimentary division occur on the east side of Hudson Bay mountain between Simpson and Toboggan creeks. The character of this division varies from place to

[1]This volume, p. 105.

place, and, apparently, expresses slight differences in the conditions of formation.

The rocks consist largely of argillites and slates, with a smaller amount of well-cemented sandstone, bands of conglomerate, and coal seams. The series as a whole is greatly anamorphosed. The top of the section has been eroded, but the present thickness of the series is estimated to be about 2,000 feet.

The section near the Lake Kathlyn Coal Company's property consists, in the upper part, of hard, massive quartzite which in places shows crossbedding. This quartzite contains a number of shaly bands and a conglomerate with pebbles up to one-half inch in diameter. The quartzite grades downward through an arenaceous quartzite to a carbonaceous slate. The lower part of the slate is largely black and graphitic and locally contains matted leaves and twigs. It is shaly in places and contains a number of coal seams. These coal seams have yielded to shearing and are considerably anamorphosed, in places are even graphitic. To the north the coal seams give way to narrow bands of highly graphitic slate.

The northern exposures of the series in the valley of Toboggan creek show a gradation from argillaceous slate to slaty quartzite, crossbedded sandstones, and conglomerates. The conglomerates hold well-rounded pebbles and cobbles up to 3 inches in diameter, most of which are of dark bluish chert or a light-coloured rock resembling rhyolite.

The Upper Sedimentary division is cut by dykes and irregular masses of quartz feldspar porphyries and at several places is mineralized by pyrite, galena, and sphalerite.

Between Simpson creek and the south side of Toboggan creek the series dips west and northwest at angles slightly steeper than the slope of the mountain. In the southern part the angle of dip varies, but averages about 30 to 47 degrees.

Toboggan creek flows on a synclinal structure. The beds on the south side dip north at angles up to 60 degrees; the beds on the north side are overturned, as shown by crossbedded sandstone, gradation in grain in the sandstone, and the stratigraphic sequence.

Some part of the strata assigned here to the Upper Sedimentary division may, in reality, belong to the Skeena formation, since coal in Telkwa and Hazelton districts is usually considered to occur only in the Skeena and younger series. A few fossils were found in the sandstone, but they were so imperfectly preserved that it was impossible to identify them. In this report these sediments are tentatively correlated with the Hazelton series, as the rocks of the Skeena series in and near Glacier creek on the west side of Hudson Bay mountain are much less anamorphosed and have a basal conglomerate containing large, angular fragments and boulders of the volcanic rocks.

Skeena Formation

A series of sediments outcropping in and near Glacier creek is correlated with the Skeena formation. These sediments outcrop over an area of about a square mile between an elevation of 3,700 feet and that of the valley floor at 2,700 feet. Sediments of this series also occur in Pass creek from an elevation of 3,600 feet to near the junction of Pass creek and Zymoetz river, and westward to MacDonnell lake. About 18 miles down

Zymoetz river from Glacier creek, another area of this series occurs where a number of coal seams outcrop. On a hurried trip to Doughty across that part of Hudson Bay mountain lying north of Silver lakes, the writer found, about 3 miles west of the railway in the bed of Sheedy creek, outcrops of sandstone and conglomerate which closely resemble rocks of the Skeena series.

On the slopes of Glacier Creek valley a coarse conglomerate forms the base of the Skeena formation. The conglomerate contains boulders and fragments up to one foot in diameter and consisting of rocks similar to the underlying Hazelton volcanics. The coarse conglomerate grades into a finer conglomerate with pebbles up to one-half inch diameter. This is overlain by a dark-coloured shale containing vegetable remains in the form of matted leaves and twigs, and grading into a black carbonaceous shale. A number of coal seams are reported in the series, but they were not examined by the writer.

The sediments of the Skeena formation occur in a number of patches which in all cases lie in valleys or low ground. It is possible that formerly they extended to higher elevations, but if so erosion has removed them. These sediments in many places are folded and faulted to a considerable extent. Near Glacier creek strikes were noted varying from north 20 degrees west to north 40 degrees west and dips from 20 degrees to 70 degrees westward. The dips are into the valley and become gentler at lower elevations.

The writer believes that on Hudson Bay mountain the Skeena series rests unconformably on the Hazelton series. At Glacier creek the Upper Sedimentary division of the Hazelton series is missing and the Skeena formation rests directly upon the underlying volcanics. The relations between the two formations have not been definitely determined, but the presence of a coarse conglomerate at the base of the Skeena series and the difference in the degree of anamorphism of the two formations indicates, as has been stated by MacKenzie[1], the existence of an unconformity.

Intrusive Rocks

Intrusive rocks on Hudson Bay mountain consist of stocks and irregular masses varying in composition from granodiorite to diorite. In addition, dykes, and possibly sills varying from diorites to quartz feldspar porphyries, are present. The stocks and intrusive masses are certainly younger than the Hazelton series and may be late Jurassic or early Cretaceous and even, in part, of Tertiary age.

STRUCTURAL GEOLOGY

Block faulting, doming, and overthrust faulting are the dominant factors controlling the structure of Hudson Bay mountain.

The southern part of the mountain has been domed, suggesting the presence of an igneous core within the mountain. Overthrusting to the north has upturned older formations southeast of Silver lakes; this overthrust was traced along the face of the mountain for several miles, but the distance to which it extends eastward is not known. Possibly the overthrust develops into a fold to the east resulting in the overturning and synclinal structure in the valley of Toboggan creek.

[1]MacKenzie, J. D.: Geol. Surv., Canada, Sum. Rept. 1915, p. 63.

The rocks of the mountain segments northeast and southwest of Pass creek have a dissimilar attitude strongly suggestive of block faulting. The volcanic rocks underlying the mountain southwest of Hudson Bay mountain have a prevailing north-northwesterly strike and dip to the southeast, suggesting the presence of a fault along the trend of Pine creek and the headwaters of Zymoetz river.

Besides faulting, lines of shearing are prevalent and mineralization appears to have been confined to zones of fracture which in some cases form parallel systems. The fractures and shear zones which were favourable to mineralization are closely associated with the southern and eastern segments of the mountain, which have suffered the greatest anamorphism, deformation, and intrusion by stocks, sills, and dykes.

As far as the writer is aware no mineralization has been discovered on that part of Hudson Bay mountain lying northwest of the fault paralleling Silver creek and continuing to the north-northwest towards the mouth of Sheedy creek.

ECONOMIC GEOLOGY

Ore deposits and prospects on Hudson Bay mountain have been known for over twenty years. In some cases small tonnages of hand-sorted ore have been shipped. Previous to 1922 several of the properties were bonded, but none of them was ever developed sufficiently to prove its merit. In 1922 the Henderson and adjacent claims were bonded and developed. This is the only property which has developed into a producing mine.

The ore deposits occur in effusive andesite in many places associated with rhyolite. In one case replacement has taken place in limestone interbedded with flows and tuffs. Mineralization is also present in stocks of granodiorite and, in one case, in a conglomerate.

The deposits have formed in zones of shearing and brecciation, largely by filling of openings with vein matter, but partly by replacement of the rock. The veins are banded in some exposures, but in places banding gives way to or is obscured by brecciation, the vein being composed of ore minerals cementing fragments of the wall-rock. In brecciated zones the rock fragments are in many cases rimmed with quartz, enclosing ore minerals in a manner characteristic of fissure filling. These fragments in many instances are partly replaced by ore, showing that replacement has accompanied fissure filling. The extent to which replacement has taken place appears to be due principally to the character of the rock. The rock most suited to replacement is limestone and the mineralization in the limestone bed on the Silver Creek property is the only deposit which can be classified as a true metasomatic replacement deposit.

The distribution of the ore deposits suggests a general focal centre from which the ore minerals were introduced. This view is further substantiated by a zonal distribution of the ore on the western slope of the mountain where a gradation exists from pyrrhotite-sphalerite ore through sphalerite-chalcopyrite to a galena-sphalerite type.

The fissures in which the ore occurs form at least two fairly regular systems, striking nearly at right angles. One system with a northeast trend is prominently developed on the western slope of Hudson Bay mountain and is represented there by the following properties: Henderson, King Tut, Coronado, Victory, and Mamie. The second, northwesterly trending fissure system is best developed on the eastern slope of the mountain and includes the Empire, Dorothy, Yukon, and Canadian Citizen properties. The veins of the Silver Creek, Rico Aspen, and White Heather properties, located on the northern slopes of the mountain, probably belong to the northeasterly trending system. Fissures on the Cascade property on the eastern side of the mountain are not parallel to the general trend of veins on this slope. The veins on several other properties do not seem to belong to either of the two general systems of fracturing. Such discrepancies are exceptions rather than the rule. A number of shear-zones and dykes which intersect the veins on the western slope are not noticeably mineralized. In general these dykes are later than mineralization and in the Henderson mine offset the vein where the two intersect.

Two, if not three, periods of mineralization appear to be evident on the Silver Creek property. Ore consisting essentially of pyrrhotite, sphalerite, and pyrite is possibly intersected by a galena-sphalerite vein which, if it cuts the pyrrhotite-sphalerite-pyrite deposit, represents a second period of mineralization. This vein has been brecciated; in part galena has flowed, and in part the ore is entirely brecciated and cemented with a calcite-quartz gangue. Chalcopyrite was introduced subsequent to brecciation; it occurs in the quartz matrix, rims brecciated fragments of ore, and has replaced galena and sphalerite. The chalcopyrite thus was introduced during what appears to be a third period of mineralization.

Movement has taken place subsequent to mineralization in a number of the veins, as shown by the results of shearing which produced gneissic galena enclosing fragments of other minerals. Gneissic galena is the rule on the Victory property, and was also observed on the Coronado, Henderson, Empire, and Silver Creek properties.

Chalcopyrite is later than sphalerite or galena in ore specimens from the following properties: Silver Creek group; Henderson mine; prospect northeast of Henderson; Dorothy group. Chalcopyrite and galena are later than sphalerite in the vein on the Empire group. This later age of chalcopyrite, together with the evidence of shearing on the Silver Creek, Victory, Coronado, Henderson, and Empire properties, suggests a distinct period of mineralization marked by the introduction of chalcopyrite. The writer wishes to emphasize the fact that only in the case of the Silver Creek property is the evidence conclusive that the chalcopyrite was introduced during a later distinct period of mineralization. In the other cases, though the chalcopyrite is later in age than the other ore minerals, yet all may belong to one period of mineralization.

The alteration and bleaching of the wall-rock of the mineralized veins is a conspicuous feature of the ore deposits. The bleaching is so pronounced in some cases that it is necessary to choose specimens of the wall-rock 8 or 10 feet away from the vein before the identity of the rock is apparent. The following description of this alteration traces the changes from normally altered andesite porphyry to its highly altered phases. These changes are due almost entirely to hydrothermal alteration and consist of sericitization, prophylitization, and silicification, all believed to be due to the action of solutions introduced at the time of mineralization. Locally, the products of weathering have, in part, masked the earlier changes.

The fresh rock is a hard, dense porphyry with light-coloured feldspar phenocrysts in a darker, bluish-grey to purplish green matrix. Such rock grades into a bleached, greyish rock having the appearance of a fine-grained rhyolite. The successive rock phases exhibited in any cross-section from unaltered to altered rock do not necessarily indicate successive stages of alteration, but they do indicate the mode of alteration.

In the outer zone alteration has taken place along fractures or veinlets which cut indiscriminately across phenocrysts and groundmass. In the fine-grained groundmass the altered areas usually have distinct boundaries, but in the feldspar phenocrysts the whole individual in many cases is partly altered, especially along cleavage or twinning planes. In other instances the altered material surrounds the phenocrysts. The alteration, which is in part a replacement, consists in the development of sericite, chlorite, and cherty quartz, in many cases forming distinct veinlets. Veinlets of chlorite are rimmed with chert and in some instances are cut by sericite stringers. Sericitization thus appears to be later than the development of chert veinlets. Where a veinlet of sericite cuts across the chert it follows a very narrow fracture or a number of fractures, but the sericite veinlet is appreciably wider on both sides of the chert veinlet. The sericite veinlets in the chert may approximately represent the size of the fractures along which solutions advanced, since the chert presumably was more stable than the groundmass and yielded less readily to sericitic alteration.

A more intense phase of alteration shows a broadening of the affected areas bordering the veinlets, giving rise to zones of replacement in which the groundmass is altered to a greater degree than the phenocrysts. The alteration is somewhat blotchy, due to the local predominance of chert or sericite. Distinct veinlets of chlorite such as are present in the less intense phases of alteration were not observed in this stage.

With an increase in the amount of alteration small amounts of calcite occur disseminated through the rock. Numerous small gash veins of cherty quartz cut the rock and are distinctly later than the normal alteration. In the most intense phases of alteration the original nature of the rock is more or less completely masked. The original outlines of the phenocrysts, maintained until the more intense stages of alteration, are somewhat vague, due to aggregates of finely fibrous sericite that extend beyond the boundaries of the primary minerals. A trace of the former feldspar phenocrysts remains and is indicated by the sericite which develops more freely and in slightly larger fibres in the feldspar than in the groundmass. Also, the fibres of sericite formed in a feldspar phenocryst tend to be oriented in one direction. On the other hand, the groundmass, which consists largely of fine-grained feldspar and quartz, alters in a slightly different manner, for the quartz being resistant to replacement there results a fine mosaic in which the quartz individuals have interfered with the growing sericite.

The main causes of alteration have been the vein-forming processes, for the alteration is adjacent to, and increases in intensity towards, the veins. The initial stage of alteration was probably chloritization which extended beyond the zones of intense sericitization and silicification.

Most of the ore deposits are replacement fissure veins, that is, fissure veins in which a variable amount of the wall-rock has been replaced by ore minerals. Two of the veins, namely, the White Heather and Canadian Citizen, are fissure veins unaccompanied by any noticeable replacement of the wall-rock. A metasomatic replacement deposit occurs on the Silver Creek group where pyrrhotite, sphalerite, and pyrite have replaced limestone.

The ores are classified on the basis of mineral content as follows:

(*a*) Pyrrhotite-sphalerite ores with some pyrite and lesser amounts of arsenopyrite and chalcopyrite
(*b*) Sphalerite-arsenopyrite ores accompanied by chalcopyrite and pyrite
(*c*) Galena-sphalerite ores accompanied by chalcopyrite, tetrahedrite, pyrite, and, in some cases, arsenopyrite
(*d*) Chalcopyrite-bornite ores
(*e*) Magnetite-chalcopyrite ores

The ore minerals identified are: galena, sphalerite, pyrrhotite, chalcopyrite, pyrite, tetrahedrite, magnetite, arsenopyrite, bornite, chalcocite, covellite, azurite, malachite, native silver, and ruby silver. The non-metallic minerals of the veins are quartz, calcite, and siderite, but they are not abundant. The country rock is usually intensely bleached near the veins and contains chlorite, sericite, quartz, and calcite.

Table I gives a summary of the mining properties and prospects with their ore minerals and strikes and dips.

TABLE I

Tabulation of Mining Properties Showing Chief Ore Minerals and Strikes and Dips of Veins

Group	Name of property	Native elements	Sulphides									Sulfo salts			Oxides		Carbonates		Values in					Strike of vein	Dip of vein
		Silver	Galena	Sphalerite	Chalcopyrite	Pyrite	Pyrrhotite	Arsenopyrite	Bornite	Chalcocite	Covellite	Freibergite	Pyrargyrite	Tetrahedrite	Limonite	Magnetite	Azurite	Malachite	Gold	Silver	Copper	Lead	Zinc		
A	Prospect northeast of Henderson mine			x	0	0	x	x											?				x	N 10° W	Steep
	Silver Creek			x	0	x	x	0											?				x		
B	Mamie			x	0	0		x											?				x	N 70° E	Steep SE
C	Henderson	x	x	x	0	0		0			0	x	0	x	0				0	x		x	x	N 65° E	"
	Coronado		x	x	0	0									0				?	?		x	x	N 48° E	Steep
	Victory		x	x	0	0														0		x	0	N 55° E	"
	King Tut		x	x	0	0						?		?						x		x	x	"	"
	Empire		x	x	0	0								0						0		x	x	N 25° W	63° SW
	Dorothy		x	x	0	?								0						?		x	x	N 55° W	58° SW
	Cascade		0	0				0														?	?	N 70° E	Steep
	Lone Star		x	?	0																	x		N 80° W	60° SW
	Silver Creek		x	x	0	0						0		0	0					x		x	0	N 85° E	53° S
	Rico Aspen		0	0		0														?		?	?	N 49° E	43° SE
	Carrol		?					?												0		0		SW	Gently NW
D	Canadian Citizen				x				x	0							0	0			x			N 50° W	77° SW
	White Heather	?			x				x								0	0		?	x			N 20° E	
E	Last Chance				x											x					?			N 80° W	70° N

Symbols—Major importance=x. Minor importance=0. Not definitely known=?

24854—9½

DESCRIPTION OF PROPERTIES

PROPERTIES ON THE WESTERN SLOPE OF HUDSON BAY MOUNTAIN

Henderson Mine (Duthie Mines, Limited)

The Henderson mine is owned and operated by J. F. Duthie of Seattle, Wash. It is situated at an elevation of 3,600 feet on the western slope of Hudson Bay mountain, about 15 miles by motor road from Smithers.

This property was staked many years ago by Boyd and Ashman. Early exploration consisted mainly of test pits and stripping, on what is known as the Ashman vein. In 1921 the Henderson vein was discovered about 200 feet southeast of the Ashman vein. Stripping of the Henderson vein disclosed high silver values and the property was bonded by J. F. Duthie in July, 1922. Development work on the Henderson vein was performed under the supervision of Mr. John R. Turner and in 1923 the property was purchased. In August, 1923, the Federal Mining and Smelting Company obtained a 55 per cent interest in the properties held by Mr. Duthie and a company termed Duthie Mines, Limited, was organized. Options were carried by the Federal Mining and Smelting Company until August, 1924, when all work stopped. Work was resumed by Mr. Duthie in July, 1925.

Through the courtesy of Mr. John R. Turner, Superintendent, the following statement of the output of the Henderson is presented.

No.	—	Tons	Au	Ag	Pb	Zn
			Oz.	Oz.	Per cent	Per cent
1	Previous to August, 1923	297	0·20	185	26	....
2	August, 1923, to August, 1924	1,625	0·16	122	20	....
3	1925	950	0·16	116	16	14

The area around the mine is underlain by the Upper Volcanic division of the Hazelton series. Rhyolite predominates, with a subordinate amount of andesite in the upper levels, but in depth the amount of andesite present increases. A series of dykes cut these rocks and strike in general about north-south. The largest dyke is of medium-grained diorite and is about 50 feet wide. Near the Henderson vein it is intensely altered and silicified and is sparingly mineralized with small veinlets of ore. It appears to be premineralization in age. The other dykes are not greatly altered and no mineralization was observed in them; where seen underground these dykes offset the vein and the part of the vein east of each dyke has been displaced to the south. One of the dykes which crosses the Ashman vein is sheared at the surface parallel to the vein. In general the dykes with a north-south trend, other than the large dyke, appear to be post-mineralization in age.

The ore-bearing veins occur in shear-zones striking about 65 degrees east and dipping steeply southwest. The veins are known as the Ashman vein and the Henderson vein. The development, which has been restricted to the Henderson vein because of its higher silver values, consists of three drift tunnels known as the Thompson, McPherson, and Compressor tunnels;

an intermediate level, raises, slopes, and surface stripping. The vein is exposed on the surface for a distance exceeding 1,000 feet and open-cuts expose the vein where it swells into lenses of solid mineral 18 inches broad. The Thompson tunnel at an elevation of 3,848 feet is driven on the vein for 130 feet. The McPherson tunnel, 113 feet below the Thompson, is driven 840 feet on the vein. In the McPherson tunnel mineralization is essentially continuous from the adit entrance for a distance of 520 feet, but over the remaining distance mineralization is poor and below the grade of ore. A crosscut was driven from the McPherson level to intersect the Ashman vein. This crosscut follows a barren shear-zone. From the end of the crosscut the Ashman vein was drifted on for 190 feet.

The intermediate level at an elevation of 3,691 feet is 500 feet in length. The vein on this level is faulted at a number of points. The Compressor level at an elevation of 3,600 feet was started as a crosscut. Ore was encountered at about 280 feet and from there the tunnel has been driven an additional 720 feet. The vein splits, branches, and narrows in places to less than an inch of mineral. Towards the face the vein is only sparingly mineralized.

Three winzes have been sunk from the Compressor level to depths of about 15 feet; in all three the ore and vein continued.

The ore occurs in fissure veins which in places show conclusive evidence of crustification or banding of the ore caused by the filling of open cavities. On the other hand replacement of the wall-rock has given rise to mineralization beyond the fissure walls and has partly replaced fragments of the wall-rock enclosed in ore.

Galena and sphalerite show mutual boundary relations and are closely related in age. Chalcopyrite in some cases shows mutual boundary contacts with galena and sphalerite, but in other cases it cuts through galena, sphalerite, wall-rock, and also quartz which rims the wall-rock. Pyrite in many instances accompanies chalcopyrite and has similar age relations. Tetrahedrite (variety freibergite) is closely associated with chalcopyrite. Chalcopyrite in many cases occurs as small particles in freibergite and veinlets of freibergite cut chalcopyrite. In one specimen a minor amount of covellite cuts both galena and chalcopyrite.

Quartz is contemporaneous with the sulphides. In open cavity fillings quartz precedes the sulphides, rimming the cavities and enclosing sulphides, but quartz also occurs disseminated through the sulphides.

In places the sulphides are fractured and cut with quartz veinlets. This is in ore taken at or near the surface and the quartz veinlets are probably secondary product of weathering.

Native silver and ruby silver occur as secondary products of enrichment. The native silver occurs as wire or plate silver typical of secondary enrichment. All the specimens of silver collected by the writer showed this mineral as plates in cracks clearly of secondary origin, or formed in vugs and small openings, always as a coating partly filling a cavity. Ruby silver also occurs in fine fractures or crystallized in vugs and cavities.

The following order, subject to overlapping, is the general paragenesis of the minerals: quartz, galena, sphalerite, arsenopyrite, chalcopyrite, pyrite, tetrahedrite, covellite, natural silver, ruby silver, quartz.

King Tut Property

The King Tut property is situated about three-quarters of a mile south-southeast of the Henderson mine. Development consists of a number of open-cuts and a shaft 50 feet deep. The country rock is andesitic tuffs and breccias overlying rhyolitic breccia.

The ore occurs in a sheared and brecciated zone striking north 55 degrees east. This zone is mineralized with quartz, sphalerite, galena, and chalcopyrite. Phases with drusy quartz and with rock fragments rimmed by quartz containing ore minerals are prevalent.

Mr. J. D. Galloway states that,[1] "Some very high-grade ore occurs in the vein, but substantial ore-shoots have not yet been discovered."

Mamie Group

The Mamie group is situated about one-half mile north of the Henderson mine at an elevation of 4,200 to 4,400 feet. It is owned by J. Aldrich of Smithers, and was bonded by J. F. Duthie of Seattle in 1919. In 1923, the Federal Mining and Smelting Company obtained Mr. Duthie's holdings, which included the Mamie. Development work was continued until June, 1924.

The country rock consists of andesitic flows and breccias varying in colour from dark grey to purple. A sheared and brecciated zone strikes north 70 degrees east and dips steeply southeast. Mineralization occurs in this shear zone.

Development consists of surface stripping and a number of tunnels. The upper tunnel at an elevation of 4,425 feet is driven on the vein for 165 feet. Two winzes have been sunk from this tunnel 33 and 42 feet respectively. Mineralization in the tunnel extends over a width of 3 to 4 feet. The minerals in the order of abundance are sphalerite, arsenopyrite, and chalcopyrite. Above the tunnel the vein has been stripped for 320 feet and a shaft sunk for 20 feet at an elevation of 75 feet above the tunnel.

The surface stripping shows mineralization reaching a width of 8 feet. The wall-rock is greatly bleached, brecciated, and cemented with ore minerals.

A lower tunnel 154 feet below the upper tunnel is driven along the general strike of the vein for 650 feet. Mineralization in this tunnel is poor. A number of minor stringers carry ore minerals, and in places crosscuts show a general zone of mineralization which is probably too low grade to be classed as ore. The best values appear to be in and above the upper tunnel.

A crosscut tunnel was started about 450 feet lower than the upper tunnel, but was not driven far enough to intersect the vein.

Coronado Group

The Coronado group lies about one-half mile northwest of the Henderson mine. The following description of the property is by J. D. Galloway.[2]

"The Coronado group of claims lies up the hill a short distance above the flat and only half a mile from the main trail. The property consists of two claims and a fraction, and is owned by R. J. McDonell, James Halley, and others. The claims are all below the timber-

[1]Ann. Rept., Minister of Mines, B.C., 1924, p. 96.
[2]Galloway, J. D.: B.C. Bureau of Mines, Bull. 14, p. 48 (1915).

line at elevations from 3,000 to 3,500 feet. A comfortable camp with cook-house and bunk-houses has been erected.

"The main vein on this property has been traced on the surface for at least 800 feet, and is developed by means of adit drift-tunnels and surface cuts. It strikes about north-east and dips at about 85 degrees to the northwest and is apparently a replacement vein, the wall-rock consisting largely of volcanic breccia, but, in places, it changes to diabase, felsite, and porphyrite. The main valuable mineral is galena, which carries fair values in silver, but in addition there are found sulphides of iron and zinc, occurring in a gangue which is mainly silicified wall-rock. The gold values in the ore of this property are a good deal higher than usual throughout the district.

No. 1 tunnel, which is the lowest on the hill, is in 155 feet, and has a winze down 12 feet below the floor-level; this working shows the vein to be mineralized in rather irregular bunches and to vary in width from 1 to 2 inches up to 2 feet. The best pay-streak of ore seen was at a point 110 feet in the tunnel, where there is a width of 10 inches of good-looking ore. A sample across this assayed: gold, 0·45 ounce; silver, 129·4 ounces; lead, 38·1 per cent; zinc, 14·4 per cent.

The ore taken out in the driving of this tunnel has been roughly sorted into two grades, of which there is about 25 tons of first-class ore; a sample representing an average of this assayed: gold, 0·20 ounce; silver, 46 ounces; lead, 23·5 per cent; zinc, 15·4 per cent. The winze was full of water, but it is said to have a showing of good ore at the bottom.

One hundred feet up the hill a cut 50 feet long has been made on the vein, and from the end of this the No. 2 tunnel is driven in 35 feet. There is a nice shoot of ore exposed in this tunnel; at the entrance the pay-streak is 2 feet wide, being nearly continuous for the length of the tunnel, and has a width of 10 inches at the face. An average sample taken at the face assayed: gold, 0·30 ounce; silver, 16·5 ounces; lead, 4·8 per cent; zinc, 45·3 per cent.

About 30 tons of first-class ore has been sorted out of the material taken out from this working, and there is another dump of second-class ore containing about 30 tons. Average samples of these dumps assayed as follows: first-class—gold, 0·24 ounce; silver, 51·4 ounces; lead, 27 per cent; zinc, 21·6 per cent. Second class—gold, 0·20 ounce; silver, 6 ounces; lead, 2·2 per cent; zinc, 16·5 per cent.

A short distance farther up the hill is the No. 3 tunnel which is 20 feet long. This tunnel has apparently been driven in on one side of the main vein, as what appears to be the vein is cropping on one side at the mouth of the tunnel and then passes into the foot-wall. The only mineral showing in the working is a little arsenical iron pyrites which occurs along fracture-planes, but this is of no importance.

One hundred and fifty feet farther up the hill a surface cut shows what is probably the same vein, and with a width of 10 inches, the mineralization here consisting of zinc blende and arsenopyrite.

A sample across the full width assayed: gold, 0·76 ounce, silver, 4·9 ounces; lead 0·8 per cent; zinc, 19·2 per cent. This assay is worthy of particular note, inasmuch as the gold content is much higher than any other sample. This sample contained zinc blende and arsenopyrite as the main minerals, with only a slight amount of galena.

From this point up the hill for another 800 feet, attempts have been made by stripping, etc., to find the vein, and in two or three places fractured seams containing some mineral have been found, which may be extensions of the main vein. The cut, which is highest up the hill, 1,200 feet or more from the No. 1 tunnel, shows a rather poorly defined vein about 2 feet in width, and carrying a little galena and zinc blende. No sample was taken here, but to judge by the eye the values would be low.

No. 2 Vein. Near the eastern boundary of the Coronado, on the west bank of Sloan creek, another vein has been developed to some extent. This vein is also of the replacement type, having been formed in a fractured dyke. An open-cut 15 feet long forms the approach to a 60-foot tunnel driven on the vein, which strikes about north 60 degrees east, and dips quite steeply to the northwest. The tunnel was commenced on a seam showing some nice galena, but after a short distance this stringer apparently goes into the foot-wall, and another seam is followed to the face. A crosscut to the northwest 12 feet long has been made at the face, but did not find anything; if the crosscut had been made in the opposite direction it might have picked up the seam on which the tunnel was started, and which lies in the foot-wall. A few tons of ore has been taken out of this working, which will assay about 0·40 ounce gold; 57·2 ounces silver, 30·2 per cent lead, and 18 per cent zinc.

A shaft has also been sunk on this vein to a depth of 15 feet, which shows ore up to 18 inches in width for 10 feet down from the top. Below this the shaft was filled with water, so that it was impossible to see what the vein looked like there. A few surface cuts also show the vein in different places, one of these showing 6 inches of galena and most of the others just disseminated mineral.

It will be of some advantage to consider the assays of the different samples taken from this property, and for this purpose they are now tabulated as follows:

No.	Description	Gold	Silver	Lead	Zinc
		Oz.	Oz.	Per cent	Per cent
1	No. 1 tunnel, sample across 10 inches	0·45	129·4	38·1	14·4
2	No. 2 tunnel, average vein at face	0·30	16·5	4·8	45·3
3	Open-cut, vein 10 inches wide	0·76	4·9	0·8	19·2
4	First-class ore-dump, No. 2 tunnel	0·24	51·4	27·0	21·6
5	Ore dump, No. 1 tunnel	0·20	46·0	23·5	15·4
6	Second-class ore dump, No. 2 tunnel	0·20	6·0	2·2	16·5

From a comparison of these results it will be seen that the silver content is dependent on the lead content, varying from about 2 to 3·4 ounces of silver to the unit of lead. By comparing Nos. 1 and 2, and 5 and 6, it can be seen that the silver is in no way related to and is evidently not contained in the zinc. Turning to the gold content, it is not so evident what relationship, if any, exists between it and the other metals. The gold does not vary proportionately with the silver, lead, nor zinc, and, in fact, seems to be quite independent of these. The writer believes, though, that the gold occurs in association with the arsenopyrite which is found in the ore. To some extent this is proved by No. 3 sample, which consisted almost entirely of arsenopyrite, zinc blende, and a siliceous gangue; it will be noted that this sample contained a good deal more gold than the others, and, as it also contained a higher percentage of arsenopyrite, it is reasonable to assume that the gold is carried in this mineral. As a rule, this arsenical iron has been considered as of only slight value in this district, but it is quite possible that in many instances it carries good gold values, and that in rejecting it from samples, as is generally done, the prospector is unintentionally throwing away the best of the ore."

Since the above report on the property was written additional work has been done. Early in 1919 the Skeena Mining and Milling Company was organized to develop the Victory and Coronado groups. The company started operations in the spring, but stopped work during the summer. A start was made again in October, but shortly thereafter work was again stopped. The lower tunnel on No. 1 vein has been driven a total distance of 240 feet. No. 2 tunnel is driven 90 feet. The tunnel on No. 2 vein has been driven an additional 10 feet. There are about 8 inches of galena and sphalerite on the foot-wall side of the tunnel, below a slip dipping 70 to 80 degrees northwestward. If the ore stays below this slip the tunnel is now on the hanging-wall side of the ore.

Victory Group

This group, owned by Donald Simpson, consists of the Victory, Standard, and Triumph claims. It lies about a mile northwest of the Henderson mine. A wagon road from the property joins the Smithers-Henderson road below the Henderson mine.

The following account of the property is by J. D. Galloway.[1]

"This property lies to the west of the Coronado group and consists of the Victory, Standard, and Triumph claims. It is owned by Donald C. Simpson, who staked it some ten years ago, and since then has, single-handed, done a considerable amount of develop-

[1] B.C. Bureau of Mines, Bull. No. 4, pp. 50-51 (1915).

ment work. The three claims are staked up and down the hill, or roughly in a north-and-south direction. The Victory is the central claim and on this the greater part of the work has been done. Several veins have been found on the property, but as yet only the No. 1 vein has been developed to any great extent. These veins are all developed in sheared zones, and are probably connected more or less directly with intrusive dykes; as a rule, the mineralization has been by means of replacement, accompanied by silicification of the wall-rock.

No. 1 Vein. This vein has a strike of north 62 degrees east and dips to the southeast at 80 degrees. It runs roughly up and down the hill, and is, therefore, well situated for the driving of drift-tunnels along the course of the vein. The lowest, or No. 1, tunnel has a length, including the approach, of 90 feet. This working shows a good shoot of ore from the portal of the tunnel inwards for about 25 feet; the width of the vein in this section being from 1 to 2 feet. Beyond this the vein is split up and seems to go into both walls, while at the face there is some mineralization, with iron sulphides, but no ore. From this tunnel about 10 tons of sorted ore has been taken out, a sample intended to represent an average of this assayed: gold, 0·18 ounce; silver, 78·1 ounces; lead, 52·8 per cent; zinc, 11·3 per cent. The whole shoot of ore exposed in the beginning of the tunnel would not assay quite as well as this sample, as the latter was taken from sorted ore.

Above the tunnel the vein has been stripped on the surface for some distance, where it can be seen that the mineralization is spotted and irregular. At a point which would only be a short distance beyond the face of the tunnel, but on the surface, there is another shoot of ore from 15 to 20 feet long and from 12 to 15 inches wide. A sample taken across 14 inches here assayed: gold, 0·13 ounce; silver, 33·7 ounces; copper, 1·5 per cent; lead, 23·6 per cent; zinc, 36·6 per cent.

A short distance above is the No. 2 tunnel, which is 10 feet long. The face shows several seams of mineral scattered across a width of 4 to 5 feet. A sample was chipped out across 4 feet 6 inches which returned on assay: gold, 0·30 ounce; silver, 16·3 ounces; lead, 9 per cent; zinc, 12·4 per cent. Above the No. 2 tunnel there are a series of open-cuts extending up the hill to the No. 3 tunnel, which disclose irregular mineralization along the vein.

No. 3 tunnel has an approach of 15 feet and only a few feet of actual tunnel under cover. At this place there are narrow stringers of mineral disseminated across 7 to 8 feet. A sample taken across 6 feet at this place assayed: gold, 0·10 ounce; silver, 2·5 ounces; lead, 1·6 per cent; zinc, 5·3 per cent. The dump from this tunnel seems to be fairly well mineralized and would probably average slightly better than the above sample.

No. 4 tunnel has a long open-cut approach, but is hardly under cover as yet. This working shows more solid ore than in the Nos. 2 and 3 tunnels. At one section, 5 feet from the face, there are two parallel streaks of ore 12 and 8 inches wide respectively, separated by a strip of waste. A sample of this ore assayed: gold, 0·44 ounce; silver, 15·4 ounces; lead, 12·6 per cent; zinc, 13·8 per cent. A few tons of good-looking ore has been saved from this working, while the waste-dump contains a fair percentage of mineral. Open-cuts and stripping between tunnels Nos. 3 and 4 also show a fair amount of mineralization. Above No. 4 there is one more exposure of the vein, but it is unimportant. From No. 1 tunnel to this uppermost cut is about 1,500 feet, and it may be said, therefore, that the continuity of the vein is proved for this distance.

No. 2 vein lies about 300 feet east of No. 1 and is roughly parallel; this is really a dyke about 1 foot wide, altered to some extent by iron- and silica-bearing solutions; no ore is visible in this vein and no work of importance has been done on it.

No. 3 vein lies 50 feet to the east of the No. 2 vein. An open-cut 24 feet long, with a 12-foot face, shows a small fissure from 6 to 12 inches wide which has a core of 3 inches of galena and on either side red oxidized material. A sample across 10 inches, including the 3 inches of galena, assayed: gold, 0·16 ounce; silver, 53·9 ounces; lead, 33·2 per cent; zinc, 4·3 per cent.

Two or three other veins or slightly mineralized dykes are known, but as yet they have not been developed to any extent; one of these, containing only arsenical iron, is said by the owner to carry fair gold values."

Since the foregoing description was written additional development work has been done. The most important work is on No. 4 tunnel (situated at an elevation of 4,080 feet). This tunnel is driven 45 feet on the vein, which is 18 inches to 30 inches wide. The minerals consist of galena, sphalerite, arsenopyrite, pyrite, and chalcopyrite.

Other Properties

Northeast of the Henderson mine, at an elevation of 4,475 feet, claims are staked on a shear-zone, in andesite. The shear-zone strikes north 70 degrees east and dips steeply. Trenching shows some mineralization consisting of arsenopyrite, sphalerite, and pyrite.

Farther to the northeast at an elevation of 5,575 feet an adit has been driven for 15 feet along a shear-zone in a tuffaceous breccia, striking north 10 degrees west. Mineralization consists for the most part of fissure filling. Quartz crystals rim the wall-rock and enclose pyrrhotite, arsenopyrite, pyrite, sphalerite, and some chalcopyrite. Mineralization from 9 to 18 inches wide is exposed in the face of the tunnel. The following order with overlapping is the general paragenesis of the ore minerals: arsenopyrite, pyrrhotite, sphalerite, and contemporaneous chalcopyrite and pyrite. Arsenopyrite is cut by veinlets of pyrrhotite, sphalerite, and chalcopyrite and is replaced by them. Pyrrhotite is earlier than chalcopyrite and pyrite, and in general is earlier than sphalerite, but in one case pyrrhotite was observed along cleavage planes of sphalerite. Chalcopyrite cuts sphalerite in veinlets and replaces it along cleavage planes.

Chalcopyrite replaced arsenopyrite and sphalerite with apparent ease, but replaced pyrrhotite with difficulty. On the other hand, pyrite replaced pyrrhotite, but occurred very sparingly in arsenopyrite. Veinlets cutting arsenopyrite and pyrrhotite contain pyrite and chalcopyrite in a calcite and quartz gangue. Pyrite has developed alongside pyrrhotite by replacement of pyrrhotite. Where two veinlets intersect, a local replacement of pyrrhotite by pyrite occurs on a large scale. Where these veinlets cut arsenopyrite, pyrite is absent and chalcopyrite replaces arsenopyrite.

PROPERTIES ON THE EASTERN SLOPE OF HUDSON BAY MOUNTAIN

Empire Group

The Empire group is owned by Donald Simpson and consists of three claims situated in a basin at the head of the south fork of Simpson creek. A good trail 6 miles long connects the property with Smithers. The country rock consists of andesite flows and breccias.

A vein on the southern side of the basin strikes north 25 degrees west and dips 63 degrees southwest. On the northwest side of the basin a vein—possibly a continuation of the vein on the south side—strikes north 25 degrees west and dips 67 degrees southwest.

Development consists of surface stripping and a tunnel on each vein. Mineralization extends over a width of 16 inches with solid ore varying up to 2 inches in width. Ore minerals are galena, sphalerite, pyrite, and some chalcopyrite and tetrahedrite. A grab sample of roughly sorted ore assayed: gold, 0·04 ounce; silver, 39 ounces; lead, 41·5 per cent; zinc, 20 per cent.

Where a mixture of ore minerals occurs, sphalerite and pyrite were the first to form. In banded ore sphalerite rims the wall-rock and in turn encloses pyrite. At a later period galena, calcite, and minor amounts of chalcopyrite and pyrite formed. Galena and chalcopyrite are closely related in age and the two occur together in minute veinlets in calcite.

Galena cuts through and replaces sphalerite and pyrite. Minor amounts of tetrahedrite are present, but in the specimens collected its relative age is indefinite. Mineralization was followed by shearing which produced a gneissic structure in some of the galena.

Dorothy Group

The Dorothy group consists of three claims owned by Frank and Harry Wade. It is west of and adjacent to the Empire group at the head of the south fork of Simpson creek.

Exploration consists of surface stripping and an open-cut. Several small veins occur in a shear-zone striking about north 55 degrees west and dipping southwest about 58 degrees. The maximum width of ore observed was 10 inches and consists of galena, sphalerite, chalcopyrite, and minor amounts of tetrahedrite. At the time of examination insufficient work had been done to determine the length of the vein.

Sphalerite and galena are closely related in age; they occur together in small veinlets and have mutual boundary relations. Chalcopyrite cuts through and replaces galena and sphalerite. Tetrahedrite is closely related in age and occurs with chalcopyrite.

Yukon Group

The Yukon group was staked by Thompson and Chism in 1924. The claims are situated about one-half mile north of the Empire group on the north side of the north fork of Simpson creek. The country rock consists of andesite flows cut by diorite. A shear-zone cuts through andesite and diorite, striking north 40 degrees west and dipping 60 degrees southwest. At the surface this shear-zone is leached and weathered. It has been stripped and several prospect pits sunk for a few feet. Weathered material from the sheared zone contains quartz, pyrite, sphalerite, and a mineral resembling tetrahedrite. Secondary products of weathering are present in the form of limonite and malachite.

Cascade Group

The Cascade group, owned by A. S. Miller and M. E. LeBlanc, is situated at an elevation of 3,600 feet on the south side of Simpson creek and about 3½ miles from Lake Kathlyn station, or 2 miles from the railway. An upper tunnel exposes a vein striking north 70 degrees east and dipping northwest. This vein contains sphalerite and galena. Mineralization in places extends over a zone 4 feet wide. Lower down the creek a tunnel extends into the hill-side for about 200 feet. A crosscut from the tunnel end was being driven and had advanced 60 feet at the time of examination. A number of shear planes exposed in the crosscut strike north 55 degrees east and contain very scattered mineralization of sphalerite, arsenopyrite, and galena. The results of prospecting so far are not indicative of a commercial ore-body.

Lone Star Group

The Lone Star group consists of six claims situated 1½ miles from lake Kathlyn in a southwesterly direction and owned by Jennings Bros. The workings are at an elevation of 2,575 feet. The property was not visited by the writer. The following description is taken from the Annual Report of the Minister of Mines for 1916.

"The formation consists of andesitic tuffs, breccias, and highly altered sedimentaries; in many places the rocks are decomposed, crumbly, and badly weathered. Some lines of shearing and sheeted zone can be seen, but at no place is there any great width of crushed rock. The most predominant strike noticed was north 50 degrees west (magnetic) with a southwesterly dip of 60 degrees. Slight mineralization has taken place along cracks and narrow shears, but no continuous streak of ore of appreciable width has yet been found. It was hoped by the Jennings Bros. that there was sufficient mineral disseminated all through the rock matter to make a large, low-grade body of ore, but, while this is a possibility, it cannot be said that such is yet proved.

Three tunnels have been driven in, two on the north side of the creek and one on the south, which prospect likely looking mineral-bearing zones. The tunnel on the south side is 100 feet long with a 22-foot crosscut from the end. This working shows a little mineral in seams an inch or 2 wide. The upper tunnel on the north side is 70 feet long and the other one is 150 feet long. The solid galena that is found occasionally in the small seams carries nearly an ounce of silver to the unit of lead. A little zinc-blende is sometimes also found."

Canadian Citizen

This prospect is owned by Cortello and partner. It is situated about 2 miles from Smithers and lies west of the Smithers-Henderson road at an elevation of 2,180 feet.

The country rock is andesite overlain by andesitic breccia. Mineralization occurs in a shear-zone, striking north 50 degrees west and dipping 77 degrees southwest.

The chief exploration consists of an open-cut 20 feet long normal to the shear zone. The wall-rock of this zone is intensely bleached. The ore minerals are chalcopyrite, bornite, chalcocite, and malachite. Mineralization is confined to veins in the shear-zone and no replacement of the wall-rock was observed. The veins vary in width from narrow stringers up to 1 inch.

Bornite cuts chalcopyrite and is as a rule later than it. Small gash veins in the bornite are filled with chalcopyrite, suggesting that some chalcopyrite was introduced subsequent to the formation of bornite. Chalcocite cuts both bornite and chalcopyrite and is later than them. Malachite and azurite are present and are a secondary product of weathering.

PROPERTIES ON THE NORTHERN SLOPE OF HUDSON BAY MOUNTAIN

Silver Creek Group (Iron Vault Group)

The Silver Creek group is situated at an elevation of 5,600 feet to 5,900 feet, on the northwest slope of Hudson Bay mountain overlooking the pass between Silver and Toboggan creeks. The group is owned by Peter Schufer of Smithers, B.C., and partners. The property is easily reached by a pack trail, about 9 miles from lake Kathlyn or 12 miles from Smithers.

The property was bonded in the autumn of 1910 to the Hudson Bay Mining Company, who carried on development work in 1912, 1913, and 1914. The option was given up shortly after the commencement of the world war. In 1917 the owners shipped 5½ tons of hand-sorted silver-lead ore to the Trail smelter. In the autumn of 1918, 30 tons of silver-lead ore was shipped to the Silver Standard Concentration at New Hazelton.

Exploration has continued on the property each year. In 1925 the property was bonded by the British Canadian Silver Corporation, a subsidiary of the British Columbia Silver Mines, Limited, of Premier, B.C.

The country rock consists of andesitic flows, tuffs, and breccias, interbedded with a limestone bed about 60 feet thick. A stock of granodiorite cuts through the series. The limestone and volcanics are part of the northwest limb of an asymmetrical syncline plunging to the northwest. The axis of the syncline is about one-half mile to the southwest. The limestone is slightly overturned and dips steeply to the east. A change in strike of the limestone has formed a steeply pitching anticlinal structure. In depth the limestone should reverse its dip to conform with the major syncline.

Mineralization occurs chiefly in the flows and limestone. The granodiorite stock is mineralized at a number of places by fissure veins. Three distinct types of ore occur on this property: (1) galena-silver type; (2) pyrrhotite sphalerite type; (3) arsenopyrite type.

(1) *Galena-silver Type.* A fissure vein, striking north 85 degrees east and dipping south 53 degrees, cuts through andesite flows and limestone and extends into a series of tuffs. Mineralization in the vein where it cuts the flows consists of galena, sphalerite, pyrite, tetrahedrite, and chalcopyrite. The vein varies in width, reaching a maximum of about 18 inches. Where the vein cuts the limestone, mineralization extends over a width of 10 feet and consists of pyrrhotite, sphalerite, pyrite, galena, and minor amounts of chalcopyrite. The vein extends through the limestone into tuffaceous rocks where it is exposed in a test pit. Development of the vein consists of three drift tunnels and surface stripping. The upper or No. 3 tunnel at an elevation of 5,900 feet is driven a distance of 98 feet on the vein. At the entrance the vein is 18 inches wide, but narrows towards the face. No. 2 tunnel is driven for 40 feet at an elevation of 5,860 feet. There is a sheared zone on the hanging-wall side of the tunnel, and 18 feet from the entrance the tunnel enters the hanging-wall. This zone is about 1 foot wide and contains sphalerite, galena, and chalcopyrite in stringers and lenses. A small, slightly mineralized calcite vein extends along the foot-wall side of the tunnel. No. 1 tunnel is at an elevation of 5,820 feet. It follows a shear-zone along the foot-wall for 38 feet. At the face a vein dips south 48 degrees. This vein pinches and swells, reaching a maximum width of 5 inches, and contains 2·5 inches of ore minerals, chiefly sphalerite, pyrite, and galena. Calcite constitutes the greater part of the gangue. Much of the ore observed in the silver-lead vein is brecciated and cemented with calcite and some quartz; the brecciated fragments consist of ore minerals.

Shearing subsequent to mineralization has in part masked the relation of the ore minerals. During shearing galena flowed and possibly in part recrystallized while the other ore minerals fractured. This resulted in galena being forced into the other minerals, giving the false appearance of being later. In many cases flow lines in the galena are observable where it has flowed around or been forced into fractures in the other minerals. More intense movement has brecciated all the ore and produced fragments of ore cemented in a matrix consisting of calcite, quartz, and small particles of ore. Some of the larger fragments, up to one-half inch in diameter, show galena cutting sphalerite, but flowage lines in the galena indicate that it was forced into the sphalerite before final brecciation. Following brecciation, quartz, calcite, and chalcopyrite were introduced; the chalcopyrite occurs in the quartz and extends into, replaces, and rims fragments of ore, giving definite evidence of its relation to later mineralization.

(2) *Pyrrhotite-sphalerite Type.* A pyrrhotite-sphalerite zone occurs 100 feet north of the silver-lead vein. A shaft and test pits following a limestone band for several hundred feet expose this zone. Four test pits along the limestone horizon show that mineralization occurs at intervals over a length of 900 feet from the shaft. These test pits are too widely spaced to indicate that mineralization is continuous between them and no statement of the continuity of the ore is warranted until further trenching or surface stripping has been completed.

East of the shaft a fissure cuts across andesite flows. The fissure strikes east-west and dips 70 degrees north. A tunnel has been driven along this fissure for 120 feet at an elevation of about 5,720 feet, but no ore is exposed in it.

The pyrrhotite type of ore appears to be largely confined to the limestone horizon. The distribution of the ore, supplemented by a study of ore specimens, indicates that it is a metasomatic replacement deposit. The ore minerals are: pyrrhotite, sphalerite, pyrite, and in some cases arsenopyrite.

Two samples of the pyrrhotite sphalerite ore assayed.[1]

Gold	Silver	Lead	Zinc
Oz.	Oz.		Per cent
0·14	1·5	Nil	16
0·02	1·4	Nil	13

The broad relations indicate one period of ore introduction, but a regular sequence of events is suggested from a study of polished sections of ore. The paragenesis of the ore minerals appears to be governed by the mobility of the minerals, possibly controlled in part by a temperature gradient. Whatever the governing causes may have been, pyrite appears to have been more mobile than sphalerite or pyrrhotite and has preceded these minerals, migrating and replacing the country rock ahead of them. Where replacement was arrested at an early stage, the pyrite occurs in scattered, well-developed cubes. Such phases grade into others where, with more complete replacement, the cubes have grown together, giving a massive replacement of pyrite. Brecciation of this pyrite has permitted the introduction of pyrrhotite in the fractures and from these fractures replacement of pyrite by pyrrhotite has progressed, accompanied by replacement of pyrite by sphalerite. The relations of pyrrhotite and sphalerite suggest that they belong to the same period of mineralization, but that in general pyrrhotite is earlier than sphalerite. From the foregoing description it is not to be understood that gradational contacts occur everywhere between limestone and ore. Near the shaft very sharp contacts of massive ore occur against limestone. Gradational phases of replacement were observed in the test pits west of the shaft.

[1]Report of Minister of Mines, B.C., 1916, p. K 123.

Where the previous described silver-lead vein crosses the limestone bed a zone is mineralized for a width exceeding 10 feet. The ore is a mixture of the pyrrhotite-sphalerite and the silver-lead types, pyrrhotite, sphalerite, and pyrite predominating. This is the only place where galena was observed in the pyrrhotite-sphalerite ore. Galena cuts both pyrrhotite and sphalerite and in some cases cuts sphalerite and rims pyrrhotite in a manner suggesting that galena is later than pyrrhotite and sphalerite. This evidence is not conclusive, because the harder minerals may have suffered fracturing, whereas the galena has undergone flowage and recrystallization, thus perhaps giving the appearance of later age. Nor is the slight shearing which crosses the limestone sufficient evidence to prove the galena vein to be later than the pyrrhotite-sphalerite deposit, because the galena vein, as shown by brecciated ore in the upper tunnel, has also been sheared. In the tunnel the ore occurs as fragments cemented in a matrix largely composed of calcite. However, the evidence strongly suggests (but does not prove) that the galena vein is later than the pyrrhotite ore.

(3) *Arsenopyrite Type.* A few shear-zones occur in the granodiorite, some of which are mineralized with arsenopyrite, sphalerite, and chalcopyrite. A tunnel is driven on a shear-zone striking east-west and dipping steeply. The tunnel was not examined because the entrance was blocked with snow. A number of test pits in the granodiorite expose some mineralization which does not appear to be extensive.

White Heather Group

The White Heather group is situated above the Iron Mask group at an elevation of 6,650 feet. The country rock consists of steeply dipping, reddish volcanic tuffs and breccias.

A brief description of this prospect is given by Mr. Galloway[1] as follows:

"The ore is found in small, irregular fissures which are often faulted considerably in small, step-like faults. The main showing is a vein which varies in width from a mere seam up to nearly a foot, which has been developed by open-cut stripping and one shallow shaft or prospect pit. The valuable minerals found are bornite and grey copper and occasionally some native silver. This vein is cut into slabs of about 10 feet in length by fault-planes, and it is very evident that the ore is better near where a fault-plane intersects the vein. Mineralization also occurs in places along the fault-plane.

Where the vein is well mineralized it is as a rule quite small, so that the total amount of ore is not great. A few tons of ore were shipped at different times in the past from this property, and during the summer of 1916 Mr. Martin had taken out a few more tons which he expected to pack out in the fall. The ore is, of course, closely hand sorted before shipping, and this sorted ore contains a high percentage of copper and often high values in silver. A representative sample of this shipping ore taken by the writer assayed: gold, 0·45 ounce; silver, 120·1 ounces; copper, 47·8 per cent.

Two hundred feet east of the main showing there is another vein striking north 20 degrees east which is from a few inches up to 2 feet in width. The vein filling is mainly gangue matter somewhat decomposed and carrying a little chalcopyrite and a lot of limonite, and somewhat stained with malachite and azurite. A sample across 2 feet of this vein gave the following assay: gold, trace; silver, 1 ounce; copper, 4 per cent."

[1]Galloway, J.: Rept. of Minister of Mines, B.C., 1916, pt. K, p. 124.

Last Chance

The Last Chance claim, owned by O. Hanson and J. Seeley, is situated on the northern side of the divide between Silver and Toboggan creeks about one-half mile north of the Silver Creek property. Exploration consists of an open-cut and an adit tunnel driven 60 feet to intersect a shear-zone striking north 80 degrees west and dipping 70 degrees north. Scattered mineralization consists of pyrite and magnetite cut by chalcopyrite.

About one-half mile east of the Last Chance claim a tunnel is driven for about 150 feet in sandstone and conglomerate of the Upper Sedimentary division of the Hazelton series. Mineralization observed consisted of pyrite and copper staining.

Carroll Property

The Carroll property, owned by Dan Carroll, is situated on the northern slope of the valley of Toboggan creek about a mile eastward from the Silver Creek group. It was not examined by the writer and the following report is by Mr. Galloway.[1]

"Two veins are exposed on the property, which strike, roughly, southwest and dip rather flatly to the northwest. On the surface these veins are very much oxidized and leached out. They vary in width from 2 to 4 feet and carry in places narrow bands of galena. The balance of the vein is gangue similar to the wall-rock. Owing to snow on the ground at the time of examination it was impossible to see the surface croppings of the veins properly; but they are said to be exposed for considerable distances up and down the mountain-side by open-cuts.

The lower vein has been prospected by a tunnel 100 feet long, which shows that the vein to this depth is leached out and decomposed into loose, crumbly rock-matter. No sulphides at all were seen in the tunnel. A sample taken across 3 feet of leached vein material in the tunnel assayed: gold, 0·12 ounce; silver, 6 ounces. Another grab sample from a 3-ton dump from the tunnel returned: gold, 0·24 ounce; silver, 7·8 ounces. A sample across 18 inches of oxidized vein material in a surface cut assayed: gold, 0·36 ounce; silver, 9·3 ounces; lead, 6 per cent. It is probable that the vein at these points carried some galena and arsenopyrite which is now completely oxidized.

The upper vein is similar to the lower one and is developed by a 90-foot crosscut tunnel. This vein is also very much leached and, therefore, shows very little sulphides. At the face of the tunnel the vein is represented by streaks of leached-out material separated by bands of harder, unaltered rock. Above the tunnel an open-cut exposes the vein, which at this point carries a 3-inch band of clean galena; a selected sample of this galena assayed: gold, 0·04 ounce; silver, 160 ounces; lead, 73 per cent.

Camp buildings have been erected at an elevation of 4,100 feet; the lower tunnel is at 4,600 feet and the upper tunnel at 5,200 feet.

More extensive shoots of galena may be found in these veins below the zone of surface oxidation."

Rico Aspen

The Rico Aspen property is located on the northern slope of the northern segment of Hudson Bay mountain, about 5 miles by trail from Evelyn station. The country rock consists of flows and breccias of andesitic composition, and is cut by a number of acidic dykes. About a quarter of a mile to the south a stock of granodiorite cuts the strata.

A sheared zone strikes north 40 degrees east and dips 43 degrees southeast. The country rock is bleached to a light-coloured, fine-grained rock near the shear-zone, which, at the surface, shows slight mineralization in the form of stringers containing galena, sphalerite, arsenopyrite, and pyrite.

[1]Galloway, J.: Rept. of Minister of Mines, B.C., 1917, pt. F, p. 114.

In 1924 a tunnel was driven into the hill-side and a drift driven on the vein. Due to snow blocking the tunnel entrance the workings were not examined.

Evelyn Group

A brief description of the Evelyn group property is given by Mr. Galloway[1] as follows:

"This group of four claims is owned by Angus McLean and J. A. MacDonald of Smithers. It is situated on the northeastern slope of one of the northerly peaks of Hudson Bay mountain and about 4 miles from Evelyn station. The showings are at an elevation of about 5,000 feet on a steep slope overlooking the Bulkley valley.

The main showing is on the Fort George, where there is a wide, fractured zone, which, however, is but very slightly mineralized. It is developed by a large open-cut and some smaller ones. The metallic minerals present are pyrite, arsenopyrite, galena, and zinc blende, occurring in a gangue of altered wall-rock which in many places is highly decomposed and oxidized. The wall-rock was not identified; it is probably of volcanic origin, but considerably altered. A section in the large open-cut shows between walls: 1 foot of oxidized material with some mineralization; then 4 feet of oxidized unmineralized material; then 3 feet sparingly mineralized; and then 6 feet of light-coloured rock and a few specks of mineral. A sample across the 1 foot assayed: gold, 0·02 ounce; silver, 36 ounces to the ton; lead, 2 per cent. Another sample across the 3 feet returned: gold, trace; silver, 5·5 ounces to the ton; and a third sample across the 6 feet assayed: gold, trace; silver, 1·5 ounces. A selected sample of the ore assayed: gold, 0·04 ounce; silver, 174 ounces to the ton; lead, 26 per cent.

[1]Galloway, J.: Rept. of Minister of Mines, B.C., 1923, pt. A, p. 110.

EUTSUK LAKE AREA, COAST DISTRICT, B.C.

By J. R. Marshall

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Illustration

Map 2099. Eutsuk Lake area, Coast district, B.C. .... In pocket

INTRODUCTION

Eutsuk Lake map-area lies along the eastern margin of the Coast range in British Columbia in north latitude 53° to 53° 45′, and west longitude 125° to 126° 30′. A geological reconnaissance was begun in this area in 1924, work being confined to the part drained by Whitesail and Tahtsa lakes and rivers. In 1925 this work was extended southward into the Eutsuk Lake drainage basin, and eastward to the junction of the Eutsuk waters with those from Whitesail and Tahtsa lakes. The various formations observed were mapped in considerable detail from the head of Eutsuk lake east to the western edge of the drift-covered plateau. Thence a general reconnaissance was made to the forks of Nechako river, and westward to and including Ootsa lake. William V. Smitheringale and Carl F. Baston rendered very efficient service as field assistants during the progress of the work.

The district may easily be reached by motor from Burns Lake on the Canadian National railway, over the road leading to Ootsa, a hamlet on Ootsa lake. From Ootsa travel is by small boat to Whitesail lake, whence a portage of 1 mile leads to Eutsuk lake. From the south, the area may be entered from Bella Coola over the old pack trail. The former route is, however, the more practicable, since the large lakes and their connecting rivers are everywhere navigable.

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PROGRESS AND DEVELOPMENT OF THE AREA

During the regime of the Hudson's Bay Company, Tahtsa, Whitesail, Ootsa, and Eutsuk lakes—the headwaters of Nechako river—and the country drained by these systems, formed the hunting and trapping grounds of the Indians residing along the Nechako from its forks to Prince George. The few surviving Indians are widely scattered along the Nechako and its tributaries, but during the autumn and winter months continue to visit the area for fur and food. In the early seventies, the first white men—other than those in the employ of the Hudson's Bay Company—passed through the district as the advance party of a railway construction survey. It was considerably later, however, before the first white settler took up land. Prior to the completion of the Grand Trunk Pacific railway between Prince Rupert and Edmonton, communication with the outside was by way of the Bella Coola trail, to Bella Coola to the south, or over an equally long and arduous trail to Hazelton to the north.

The first settlement was made about 1904 on the north shore of Ootsa lake and since then growth has been slow but steady. At present there is a population of approximately one hundred, all on the north side of the lake. A few homesteads have been taken up east of the forks of the Nechako, but are not now occupied. Telephone service has been extended to Ootsa, and a stage makes the round trip from Ootsa to Burns Lake twice weekly. Four small stores have been established on Ootsa lake, two at Ootsa, a third at Wistaria, 14 miles west of Ootsa, and a fourth at the outlet of Ootsa lake. These supply the settlers with the general staples, and also function as small trading posts.

The north side of Ootsa lake is open, rolling country particularly well adapted to mixed farming and ranching, and capable of supporting a much larger population than it does at present. That settlement within the area has not been more rapid is due to a variety of circumstances, chief among which is remoteness of any large centre of population, and consequently a lack of markets for any produce which the settler might be able to send out. Burns Lake, 45 miles north of Ootsa, on the Canadian National railways, with a population of approximately five hundred, is the nearest hamlet of any size; and Vancouver and Edmonton the closest well-populated centres.

Since the land bordering the north shore of Ootsa lake affords excellent grazing and is otherwise particularly well adapted for cattle ranching, many of the settlers followed this occupation exclusively. Cattle were driven in from distant outside points, an expensive operation under the then existing conditions. Herds suffered heavy depletions from the many adversities encountered on the long trail. Long, severe winters proved an adverse factor, as stock must be fed and sheltered for six months each year. In the spring and summer noxious weeds exacted a heavy toll. Shipments of dressed beef from Ootsa to Prince Rupert netted no profits, but on the contrary resulted in losses. After several such reverses, cattle ranching dwindled, and the settlers became content to eke out a livelihood in any way the country offered. At present some, operating on a small scale, are making small profits with cattle by co-operative marketing, and by accepting merchandise as part payment.

Mixed farming is carried on and could be extended to make the community self-contained. Eggs, butter, bacon, and even roots are constantly imported from outside points. All of these could be raised within the settlement in sufficient quantity to meet all demands, and would serve as a beginning from which larger things might develop.

At present the settlement's chief source of revenue is from trapping. Fur farming on a small island in Ootsa lake has been carried beyond the experimental stages by J. Barker and has been attended with encouraging success. In recent years others have followed this example and the industry promises to develop rapidly. Seasonal occupations, such as road construction and improvement, guiding of tourists, and freighting, afford a small revenue for a limited number. Fur, however, must, for some time, continue as the steady source of revenue.

Owing to high prices commanded by fur during recent years trapping has been extremely intensive and the depletion of fur-bearing animals has become noticeable. Even now the future of this revenue-producing source is viewed with alarm. A proposal to convert a part of the district into a game preserve has been made. Enactment of such a proposal might prove detrimental to Ootsa and Wistaria and might even force some settlers to leave the district, and certainly would deter others from entering. The depletion of the fur-bearing animals, perhaps, is not so much a result of the evils of the present as of the ruthless slaughter of a generation passed. Coyotes, very numerous throughout the district, yearly take a heavy toll. There has been much illicit traffic in fur, and this alone has, perhaps, been one of the major causes of depletion.

After practically a quarter of a century Ootsa is still in the early stages of pioneering. Its future growth is directly dependent on the development of the natural resources of the vast stretch of country to which it is a gateway. There is an extensive belt of country for the prospector and encouraging results have attended what little prospecting has been done. The discovery of mineral in paying quantity would attract large numbers to the district and would serve as an impetus to settlement. The search for minerals is expensive and arduous, and every encouragement should be given to those desiring to engage in that search.

PHYSICAL FEATURES

Three physiographic features are prominent in the area, the Coast range to the west, the Interior Plateau on the east, and, between, a well-defined transition zone linking these two important physiographic provinces.

The Coast range consists of a number of parallel ranges trending northwest and southeast and separated one from the other by broad, but deep, canyon-like valleys. Broadly viewed the range appears as an assemblage of snow-covered, irregularly serrate peaks with a uniform crest-line, 7,000 to 7,500 feet above sea-level, but here and there broken by higher peaks rising 8,000 and even 9,000 feet above sea-level. In that part of the Coast range which borders the area reported upon the majority of the peaks attain elevations of 7,000 feet, and a few reach 7,500 feet above sea-level. The relief varies from 4,000 to 4,500 feet. Alpine glaciers, still active on the higher summits, have transformed what were formerly smoothly rounded, even summits into an assemblage of rugged, irregular peaks of forbidding aspect, in decided contrast to the more even and inviting summits of the plateau to the east.

The Interior Plateau is an undulating, hilly country with a relief varying from 200 feet in the east to 4,500 feet in the west. Viewed as a unit it appears as a comparatively even plain into which the main streams have incised broad, deep, U-shaped valleys. Otherwise dissection has made little progress. Eutsuk, Chef, and Michel peaks, and those of the Quanchus range, all of which have granite or diorite cores, and project well above the general elevation of the plateau, impart a rugged aspect to an otherwise even surface. The plateau is as a rule densely timbered with small jack-pine and spruce, dotted with many small lakes and undrained, swampy depressions, and in the eastern part floored with a thick, even deposit of glacial till. In the vicinity of Eutsuk, Chef, and Michel peaks, and on the ridges bordering the south shore of Eutsuk lake and the north shore of Tesla lake, there is an excellent growth of succulent grass, which forms good food for the wild game of the district.

Between the Coast range and the Interior Plateau there is a transition zone characterized by rounded, flat-topped mountains whose elevations gradually change from 3,000 feet in the east to 6,000 and even 7,000 feet in the west. The axes of the ridges in this transitional zone all trend at right angles to the axes of the Coast range, i.e. northeast and southwest, and the ridges appear to project from the Coast range as a series of spurs. The width of this zone is approximately 15 miles. Each ridge is a separate massif separated from its neighbours by broad, steep-sided, U-shaped valleys, also running northeast and southwest. The smooth, rounded outlines and gentle east slopes of these several blocks, together with their complete isolation, form one of the striking topographic features of the district. The low, rounded hills bordering the south shore of Eutsuk lake east and west of Pondosy bay, Chikamin and Whitesail ranges, and Core mountain, are examples. This peculiar sculpturing is equally well-defined in the open country south of Tesla lake. Dolmage mentions a similar type of topography at Chilko lake and vicinity[1] and the present writer recognized similar features in the Whitesail-Tahtsa Lakes district to the north.[2]

The ridges forming this transitional zone undoubtedly once formed part of the Coast range and possessed features similar to it. Following the partial retreat of the continental ice-sheet, which covered even the highest peaks in the area and left in its wake more or less smoothly rounded summits, huge tongues of ice remained on the higher summits, and in the pre-existing valleys. These coalesced to form an ice-sheet of lesser extent than that of the continental ice-sheet at the time of its maximum development. Well-defined glacial terraces and smoothly truncated slopes on almost all of these ridges at approximately 2,800 feet above the valley bottoms are evidences of the effective action of these ice tongues in carving the present topography.

Glaciation has been the dominant factor in moulding the present topography throughout the area. The continental ice-sheet covered the

[1]Dolmage, V.: Geol. Surv., Canada, Sum. Rept. 1924, pt. A, p. 61.
[2]Marshall, J. R.: Geol. Surv., Canada, Sum. Rept. 1924, pt. A, p. 48.

entire area, as is evidenced by the great variety and wide distribution of erratics, glacial striæ, and polished surfaces, on even the highest slopes which were rounded and planed off. Alpine glaciers subsequently carved many of these rounded summits into wildly fantastic, jagged peaks with picturesque cirques so characteristic of the Coast range. This is particularly true of that part of the Coast range bordering Eutsuk lake and the country to the west and south. In the part bordering Whitesail and Tahtsa lakes the summits are as a rule smoothly rounded and uniform in elevation. The present valleys were deeply scoured and widened by valley glaciers and the interstream areas deeply dissected. Erosion was dominant in the western part of the area, as evidenced by the well-dissected nature of the country. East of a line joining Eutsuk peak and mount Wells deposition was the dominant feature. In this area the plateau surface and the valley bottoms are covered with a thick mantle of glacial till which supports a dense growth of small jack-pine. Alpine glaciers still occupy many of the higher summits and extend well below timber-line.

GENERAL GEOLOGY

Table of Formations

Period	
Recent and Pleistocene	Gravel, silts Glacial till
Tertiary	Basalt, tuff
Jurassic or Later	Quanchus batholith Granite and diorite stocks Dyke rocks associated with Coast Range batholith Coast Range batholith
Jurassic	Hazelton group; andesitic and rhyolitic lavas and tuffs, sedimentary tuffs, argillites, limestones, agglomerates, breccias

HAZELTON GROUP

Rocks of the Hazelton group are widely distributed throughout the district. They consist of a thick assemblage of volcanics, both pyroclastics and lavas, and associated beds of limestone, argillite, and sedimenatry tuffs. One of the very striking features of the group is the vast amount of fragmental material which by far exceeds all other types.

The base of the Hazelton group was not observed at any point within the map-area. Near Bone creek in Pondosy bay, Tertiary volcanics dipping 30 degrees southwest overlie unconformably the coarse fragmentals of the Hazelton group. On a promontory on the south shore of Tetachuck lake, approximately 2½ miles west of its outlet, flat-lying Tertiary lavas overlie intensely deformed rocks of the Hazelton group. No accurate measurements of the thickness of the rocks of this group could be made because of incomplete sections. A partial section on Chikamin ridge and another on ridges between Bone creek, Eutsuk lake, and Pondosy bay were estimated to be at least 15,000 feet thick.

As in the Whitesail-Tahtsa Lakes area, the rocks of the Hazelton group fall readily into three divisions, a lower volcanic member, a middle sedimentary member, and an upper volcanic member.[1] A similar subdivision is made by Hanson for rocks referred to this group in the Driftwood Creek map-area.[2]

Lower Volcanic Member

Rocks of this subdivision occur chiefly on the low, rounded hills between Chikamin ridge and the west end of Whitesail lake, and also at the east end of the lake. They consist chiefly of dense, purple, green, and grey greenstone porphyries—Dawson's porphyrites. These rocks contain dull white laths of decomposed feldspar in a dense groundmass of microcrystalline feldspar, and calcite with intersertal texture. Amygdaloidal and vesicular lavas are also present, and invariably contain much green epidote. The base of this member is nowhere exposed, but the steep dips maintained by these rocks indicate a thickness of at least 5,000 feet.

Middle Sedimentary Member

Rocks of this subdivision form the greater part of Chikamin ridge, the ridges between Bone creek and Eutsuk lake, and outcrop at numerous points along the shores of Eutsuk lake. They consist of thin beds of limestone, black argillites, and waterlain tuffs, with interbeds of tuffs, agglomerates, and breccias. The tuffs, mainly of andesitic and rhyolitic composition, are purple, green, red, and blue-grey, dense to medium-grained, and commonly of even texture. They are as a rule so highly altered that their fragmental nature is discernible only with the aid of thin sections. In such cases the rocks resemble cherts, or masses of vitreous quartz, and have conchoidal fracture. These well-bedded rocks locally are impregnated with pyrite, marcasite, chalcopyrite, bornite, magnetite, galena, and zinc blende. They are exposed in sections between Bone lake and Eutsuk lake to a thickness of at least 6,000 feet, with base not shown. The mineral deposits of importance so far discovered in the district occur in the rocks of this subdivision, on Chikamin ridge between Eutsuk and Whitesail lakes, and on Sweeney mountain north of Tahtsa river.

Upper Volcanic Member

Rocks of this subdivision are well exposed on both sides of Eutsuk lake in the vicinity of Pondosy bay. They form the rounded hills between Tesla and Eutsuk lakes and outcrop at intervals along Tetachuck, Euchu, and Natalkug lakes, which lie east of the map-area. The rocks are mainly fragmental and include a great thickness of fine and coarse tuffs, coarse breccias and agglomerates, minor amounts of andesitic and rhyolitic flows, and some vesicular and amygdaloidal lavas. The rhyolites appear to occupy the top of this subdivision. As a rule the rocks of this subdivision are not as intensely deformed as those of the underlying member.

The rocks of the Hazelton group strike north 10 degrees west to north 50 degrees west and have dips of 35 to 90 degrees, the higher dips predominating. Variations in the strike occur locally. Sections examined

[1]Marshall, J. R.: Geol. Surv., Canada, Sum. Rept. 1924, pt. A, p. 50.
[2]Hanson, George: Geol. Surv., Canada, Sum. Rept. 1924, pt. A, p. 24.

show that the rocks are strongly folded, sheared, and slickensided. In St. Thomas bay highly deformed argillites show small faults and crush zones which may be indicative of larger displacements in the more massive and competent beds. In the Chikamin ridge to Bone Creek area the structure is a plunging anticline with plunge to the southeast. Chikamin ridge forms the crest of the anticline.

The rocks are everywhere highly metamorphosed. On mount Musclow, Smaby creek, and at other points within the Coast range they form roof pendants included within the Coast Range batholith and are highly schistose. The rocks on the portage between Tetachuck and Euchu lakes also are highly schistose. At numerous other points they are intensely silicified and everywhere coated with light green epidote.

Imperfectly preserved fossils of probable Jurassic age were found in the tuffs on Chikamin ridge and Sweeney mountain.[1] Similar tuffs with poorly preserved fossils and fossil impressions occur at many localities along Eutsuk lake.

Lithologically these rocks are correlated with Hazelton group rocks in the Driftwood Creek map-area to the north,[2] and with the Denain formation in Chilko Lake district.[3]

COAST RANGE BATHOLITH

The western part of the area is occupied by the Coast Range intrusives, which are younger than the rocks of the Hazelton group and are in contact with them along a line having a general northwesterly course. These rocks are very uniform in appearance and composition. They consist of diorite, quartz diorite, and granodiorite. Thin sections show the rocks to consist essentially of plagioclase, quartz, hornblende, orthoclase, with biotite, magnetite, and apatite as accessories. Plagioclase, in many cases zoned, ranges from oligoclase to andesine-labradorite. Quartz is always present in large amounts. Orthoclase occurs up to 5 per cent and always filling interstices. Hornblende, the chief ferromagnesian mineral, is deep green and strongly pleochroic. Biotite is present in small amounts and appears to increase as the rock approaches a granite.

Large quartz veins barren of any metallic mineral occur in rocks of the Hazelton group near the contact with the Coast Range batholith.

A number of small, outlying igneous masses intrude rocks of the Hazelton group near the west end of Whitesail lake, on the north shore of Eutsuk lake between St. Thomas bay and the west end of the lake, and on the south side between Pondosy and the head of the lake. These rocks consist of diorite, quartz diorite, and granite stocks. Some of the diorite masses have sheet-jointing so well developed as to give the impression of bedding. Diorite and aplite dykes cut rocks of the Hazelton group, and also the Coast Range batholith. All of these smaller intrusive masses are invariably accompanied by mineralization affecting both the intruded and intrusive rocks. All of these masses may be directly related in origin to the Coast Range batholith. They appear on the accompanying map (No. 2099) as distinct from the batholith because the known mineral occurrences in the area appear to be related directly to them.

[1]Brock, R. W.: Geol. Surv., Canada, Sum. Rept. 1920, pt. A, p. 88.
Marshall, J. R.: Geol. Surv., Canada, Sum. Rept. 1924, pt. A, p. 51.
[2]Hanson, George: Geol. Surv., Canada, Sum. Rept. 1924, pt. A.
[3]MacKenzie, J. D.: Geol. Surv., Canada, Sum. Rept. 1920, pt. A.

QUANCHUS BATHOLITH

A large part of the plateau between Ootsa and Eutsuk lakes is occupied by an intrusive mass to which the name Quanchus batholith is given. This mass forms the greater part of the Quanchus range, Michel, Chef, and Eutsuk peaks, and is composed of various rock types occupying areas that are partly concealed by glacial drift and are separated in places by masses of the Hazelton group volcanics which have been intruded by the batholith.

In the Quanchus range granite, syenite, and quartz monzonite occur. The type rock, however, is a medium-grained, even-textured, pink and grey granite, which, in places, is porphyritic. Thin sections show the rock to consist of: orthoclase 50-57 per cent; oligoclase 9 per cent; quartz 22-30 per cent; biotite 5 per cent; hornblende 5 per cent; titanite, magnetite, apatite, and zircon 3 per cent. Orthoclase, flesh-coloured, is invariably altered to kaolin. Minute grains of this mineral are replaced by quartz and plagioclase. Micrographic growths of quartz and orthoclase are common. Where the rock is porphyritic, orthoclase forms the phenocrysts. The plagioclase is finely twinned and altered to kaolin and sericite. Quartz is interstitial and occurs as micrographic intergrowths.

Near Chef peak the type rock is a medium to coarse-grained, white granite, porphyritic in places. Orthoclase and quartz are about equal in amount, and in places the only constituents. Biotite is the only ferromagnesian mineral where one is present.

Near Eutsuk peak the common type is a pink syenite composed chiefly of pink orthoclase feldspars with very subordinate amounts of biotite. Both this and the preceding type form the white ridges which are so conspicuous from the shores of Eutsuk lake.

On the south slope of Eutsuk peak the pink syenite appears to contain inclusions of grey diorite, resembling the average type of rock observed in the Coast Range batholith. Erratics were also observed in this locality showing this same relationship. Near mount Wells in the Quanchus range the pink porphyritic granite and syenite appear to contain inclusions of grey diorite, typical of the diorite of the Coast Range batholith. In some cases the lines of demarcation between the two types are sharp and well-defined, in others there is a suggestion of a gradation from one type to the other.

The Quanchus batholith intrudes rocks of the Hazelton group, and is overlain by flat-lying volcanics of Tertiary age. A notable feature is the absence of dyke rocks which are so characteristic of the Coast Range mass. Although the age relations between the two batholiths could not be definitely established, the facts that rocks of the Quanchus batholith appear to contain inclusions of diorite similar to the diorites of the Coast Range mass, that there is an absence of dyke rocks, which are everywhere found cutting the Coast Range batholith, and the difference in lithology between the two masses, suggest that the Quanchus batholith is of Cretaceous or very early Tertiary age.

TERTIARY

Tertiary volcanics occupy many of the small islands in Pondosy lake, and at the head of Pondosy bay and outcrop in the flat between these two expanses. North of Eutsuk lake they form an escarpment, and are thought to underlie a considerable part of the drift-covered plateau east of the area occupied by the Quanchus batholith.

In Pondosy bay and Pondosy lake these volcanics consist of amygdaloidal and vesicular basalts, commonly with pillow structure and columnar jointing. Interbedded with these lavas are fresh-looking, basaltic and andesitic tuffs in beds up to 15 feet in thickness. On several of the islands at the foot of Pondosy lake a volcanic conglomerate or agglomerate outcrops. This is composed of numerous, rounded and smooth pebbles almost all of which can be identified with rocks of the Hazelton group. These pebbles vary from the size of a pea to 9 inches in diameter. There is no suggestion of sorting. Commonly a mass of small, rounded pebbles and angular fragments is found wedged among the larger rounded pebbles. Angular fragments, though subordinate to rounded, are common. The matrix, which nowhere exceeds 10 per cent of the mass, is of volcanic materials, consisting of angular fragments of feldspar, quartz, and basaltic material. A few small diorite pebbles which may have been derived from the Coast Range batholith were found in the mass. These, however, are rare.

North of Eutsuk lake the Tertiary volcanics consist of amygdaloidal and vesicular basalts with well-defined columnar jointing. The rocks form a pronounced escarpment approximately 700 feet above the valley of St. Thomas creek, and paralleling the shore of Eutsuk lake. They also outcrop on the upper surface of the plateau where they occur as thin outliers resting on the rocks of the Quanchus batholith.

On Pondosy bay and Pondosy lake these volcanics strike north 30 degrees west and dip 30 degrees southwest. Elsewhere the beds are horizontal. From their areal distribution it is apparent that the rocks were extruded on a surface of considerable relief. Structural features in the area indicate that there were at least two separate periods of volcanism. The rocks of Pondosy belong to the earlier period, following which there was uplift. The Tertiary rocks of the plateau belong to a later intrusion, and probably correspond to Dawson's "Upper Volcanics"[1] which he regarded as late Miocene in age.

ECONOMIC GEOLOGY

The east border of the Coast Range batholith lies within the district. North and south of the area this zone has been proved to be favourable for the formation of mineral deposits. As yet, very little prospecting has been done in the area, and only along parts of the trunk streams. Although the district is remote, it is easily accessible, and travel is not difficult in the parts where minerals are most likely to be found. The discoveries so far made prove that mineral deposits occur and perhaps justify the

[1]Dawson, G. M.: Geol. Surv., Canada, Ann. Rept., vol. VII, pt. B, pp. 73-76 (1896).

optimism of the few prospectors who have examined parts of the district. During the seasons of 1924 and 1925 there was only one prospector in the area. Prior to 1920 claims were staked on Sweeney mountain and the adjacent ridges north of Tahtsa river, and on Chikamin ridge between Whitesail and Eutsuk lakes, and in the country bordering Tesla lake. Some development work was done on the prospects on Sweeney mountain and Chikamin ridge.[1] These are now idle.

The formations that are most favourable for the occurrence of mineral deposits are the Coast Range batholith, its associated dykes and stocks, and the sedimentary subdivision of the Hazelton group. Almost everywhere along the line of contact between the batholith and rocks of the Hazelton group, the latter are schistose, highly silicified, and otherwise metamorphosed. The numerous dykes and stocks associated with the Coast Range batholith are invariably mineralized with pyrite, chalcopyrite, galena, zinc blende, arsenopyrite, and in places bornite. On mount Musclow, Hazelton group rocks are schistified and silicified, and impregnated with sulphides. Along the contact of the batholith with the volcanics, near the head of Smaby creek, well-bedded, strongly metamorphosed Hazelton group rocks are cut by a network of quartz veins from a fraction of an inch to an inch in width. These veinlets are sparsely mineralized and the country rock is impregnated with copper and iron sulphides.

On the hills between Bone creek and Eutsuk lake the bedded rocks of the Hazelton group are invaded by many small dykes of diorite and granite. Both the intruded rocks and intrusives are impregnated with pyrite and small quantities of galena.

The sedimentary tuffs which contain the silver-lead deposits on the north slope of Chikamin river outcrop on the south slope of the ridges and carry pyrite, chalcopyrite, bornite, and galena. On Gable mountain, Hazelton group rocks are copper stained. The low, open hills bordering Tesla lake are heavily stained with limonite.

Along the contact of the Quanchus batholith with the Hazelton group rocks, pyrite is the only mineral observed. The mineralization appears of lesser importance than that along the edge of the Coast Range batholith.

At the outlet of Whitesail lake highly altered rhyolites and rhyolitic tuffs are sparingly mineralized with pyrite and chalcopyrite. One specimen was observed to carry specks of free gold.

On the portage between Tetachuck and Euchu lakes (east of the map-area), highly metamorphosed Hazelton group rocks are impregnated with pyrite and pyrrhotite. A specimen, composed almost entirely of pyrrhotite, from one locality where the mineralization seemed rather intensive, was selected to ascertain what values if any the sulphides carry. The assay[2] gave: silver, 0·54 ounce; gold, trace; nickel, none.

No large mineral bodies were observed in any part of the district. The geology, however, indicates that conditions are highly favourable for the formation of mineral deposits. Within the Coast range itself are many areas of included roof rocks, in or near which deposits of the contact metamorphic or replacement type might be expected. Along the eastern border of the batholith mineralization is sufficiently intensive and varied to justify the hope that large mineral bodies may be found.

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[1]Marshall, J. R.: Geol. Surv., Canada, Sum. Rept. 1924, pt. A, pp. 52 et seq.
[2]Assay by Dept. of Mines, Ottawa.

FUTURE OF THE AREA

The future development of the district is entirely dependent on the discovery of commercial ore-bodies. Large parts of the district, including the country from the forks of Nechako river west to the head of Eutsuk lake, from the west end of Ootsa lake to the head of Whitesail lake, and the country between Ootsa and Eutsuk lakes, are unsuitable for agriculture. Numerous forest fires have removed most of the valuable timber. Jack-pine, suitable only for railway ties, is the only timber of value remaining.

With the discovery of commercial ore-bodies, the various branches of agriculture would receive impetus, increasing population would absorb output, and improvements in transportation would be justified. Power for mining and other purposes can be made available by the development of the numerous waterfalls.

TATLA-BELLA COOLA AREA, COAST DISTRICT, B.C.

By V. Dolmage

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Illustration

Map 2103. Tatla-Bella Coola area, Coast district, B.C. .... In pocket

INTRODUCTION

The field season of 1925 was spent in making a reconnaissance topographical and geological survey of a narrow strip of country about 100 miles long, extending from Tatlayoko lake to Bella Coola, and lying between longitudes 124 : 30 and 126 : 75 and latitudes 51 : 30 and 52 : 30. This work was done as part of a general plan to explore and map the eastern contact of the Coast Range batholith, and is a continuation of the mapping done by the writer in 1924 between Taseko and Tatlayoko lakes.

The accompanying map (No. 2103) is based on triangulation nets established by John Davidson and R. P. Bishop of the Lands Department of British Columbia.

F. F. Osborne, H. S. Bostock, and A. M. Cockburn rendered valuable assistance during the field season.

The district is reached by a motor road from Williams Lake on the Pacific Great Eastern railway. This road can be used by motors during the greater part of the year as far as Redstone, a store and post office about 70 miles west of Williams Lake, but the remaining 50 miles to Tatla Lake post office can be travelled by motors during only a few months in the summer. From Tatla lake a rough wagon road extends northwest as far as Anahim lake whence a trail leads to Stuie, the site of a former Indian village in the Bella Coola valley 40 miles from Bella Coola, with which it is connected by a good motor road. Bella Coola is a seaport about 300 miles north of Vancouver. A government telegraph line extends from Williams Lake to Bella Coola along the above-mentioned roads and trails.

The only previous geological work done in the Tatla-Bella Coola map-area was in 1876 by G. M. Dawson,[1] who made a reconnaissance geological map of a large section of west-central British Columbia, including most of the area mapped by the writer. A small part of the country in the vicinity of the headwaters of Klina Klin river was described by J. D. Galloway,[2] who examined the hematite deposit near Perkins peak.

[1] Geol. Surv., Canada, Rept. of Prog. 1875-76, p. 233.
[2] Ann. Rept., Minister of Mines, B.C., 1916.

TOPOGRAPHY

The area mapped lies along the boundary between the two main physiographic provinces of western British Columbia, the rugged mountains of the Coast range on the southwest and the Interior Plateau region on the northeast. Between these two well-defined provinces lies a transitional belt from 10 to 12 miles wide, characterized by rounded and flat-topped mountains, which rise somewhat gradually from the plateau and merge into the mountains of the Coast range. The boundary between the plateau and the transitional belt passes south of Tatla lake, follows the base of the low hills lying north of One Eye lake, and thence extends to Anahim lake, where it bends northward and passes out of the map-area. The boundary between the transitional belt and the Coast range is not so well defined. It extends from the north end of Tatlayoko lake, crosses West Homathko river south of Bluff lake, continues north of Perkins peak, and thence follows a nearly straight course to Canoe station, just above Canoe crossing on Bella Coola river.

The plateau part of British Columbia occupies a belt about 100 miles wide, extending in a northwesterly direction throughout the central part of the province. Its western boundary is at an average distance of 90 miles from the Pacific coast from which it is separated by the Coast range. It is a region of low to moderate relief which is partly the result of deposition of freshwater sediments, extensive lava flows, and thick deposits of glacial till, and partly the result of mature erosion of the bedrock underlying the glacial drift and lava flows. It has an elevation above sea-level of 2,500 to 3,500 feet and into its surface Fraser river and its many large tributaries have cut deep, gorge-like valleys. The surface of the plateau is further modified by occasional volcanic mountains which rise abruptly to elevations as great as 7,000 feet. The part of the plateau lying in and adjacent to Tatla-Bella Coola map-area is almost entirely covered by Tertiary lava flows, over the greater part of which lies a thick mantle of glacial till. To the east and northeast the plateau stretches for many miles as an almost unbroken plain, the sky-line presenting no irregularities other than a few low mesas, but to the north its uniformity is interrupted by three groups of volcanic mountains and one very conspicuous volcanic cone 6,286 feet high, known as Anahim. The most westerly of the three groups of mountains lies on the northern boundary of the map-area. These mountains were formerly known to the Indians as the Tsi-Tsuti mountains, but because of the brightly coloured rocks composing them are now known to the white inhabitants as Rainbow mountains. Continuing east from these are Ilgachuz mountains and farther east Itcha mountains. All of these mountains are composed of volcanic rocks that are Tertiary or later in age.

Fringing the western edge of the plateau and separated from it by a range of low hills is a broad, open valley occupied by many swamps and shallow lakes such as Hook, One Eye, Kappan, Nimpo, and Anahim. The last two drain northwest into Dean river. The rest of the valley formerly drained southeast through Choelquot lake into Chilko river, and thence to the Fraser, but the drainage of the central part was captured by the headwaters of Klina Klin river and now is by way of this river to Knight inlet.

The transitional belt of mountains lying between the plateau and the Coast range consists of rounded and flat-topped mountains which rise gradually towards the west and within a distance of 12 miles merge into the Coast range. These rounded and flat-topped mountains are separated by deep, wide, glacially eroded valleys, the majority of which begin as cirques near the crest of the Coast range and slope in a northeasterly direction down to the plateau. A few of the valleys, however, are much larger and deeper and drain westward to the Pacific. Near where they join the plateau they are occupied by large lakes which derive their water, not from the plateau, but from the slopes of the adjacent mountains. These "through" valleys were evidently formed in part at least by tongues or lobes of the Pleistocene ice-sheet which occupied the whole region.

Owing to the presence of these through valleys an unusual drainage pattern has been developed in this district. Many large streams flowing from the crest of the Coast range and down the eastern slope instead of continuing on an eastward course across the plateau to join Fraser river, on reaching the plateau turn sharply and flow to the Pacific through one or other of the through valleys. This is particularly well illustrated by the Klina Klin (Indian name meaning "turning back to itself") which flows into Knight inlet. Four of its larger headwater tributaries rise in the heart of the Coast range, flow northeast to the plateau, where they turn and flow southwest to the ocean.

The mountains of the Coast range are composed almost entirely of granitic rocks of the Coast Range batholith carved into sharp, jagged peaks having an average elevation of 8,000 or 9,000 feet. A few are over 10,000, and at least one over 12,000, feet high. They are separated by deep, steep-walled valleys occupied in their upper parts by large glaciers, some of which are over 20 miles in length. The extremely jagged character of these mountains seems to be the result of long-continued alpine glaciation.

GENERAL GEOLOGY

The southwestern half of Tatla-Bella Coola map-area is occupied by granitic rocks of the Coast Range batholith, and the greater part of the northeastern half by widespread Tertiary lava flows. Between these two geological provinces is a belt of sedimentary and volcanic rocks, in part of Lower Cretaceous and in part of Triassic age. The contact of the batholith is very irregular and in the vicinity of Kappan lake passes beneath the lavas of the plateau. Strongly gneissic rocks in the vicinity of Tatla hill and at two localities near the big bend of Klina Klin river could not be definitely correlated with any of the other formations in the map-area, and, therefore, were mapped separately.

Table of Formations

Pleistocene and Recent	Till, clays, white silts, and gravels
Tertiary lavas	Basalt and andesite
Coast Range batholith	Quartz diorite, granodiorite, diorite, quartz monzonite
Lower Cretaceous	Sandstone, conglomerate, argillite, and volcanic breccia
Triassic	Volcanic flows, breccia, tuff, argillite, and limestone
Gneissic rocks	Quartz, feldspar, and garnet gneiss; quartz diorite gneiss

GNEISSIC ROCKS

Gneissic rocks occur in the general vicinity of Tatla hill and at the big bend of Klina Klin river near Klina Klin flats about 10 miles southwest of Tatla Lake post office. Two varieties of gneiss were observed, a banded type consisting of quartz, feldspar, garnet, and biotite, and a more massive quartz diorite gneiss found only on Tatla hill but in direct contact with the banded gneiss. The banded gneiss is strongly foliated parallel to the banding, which strikes north 70-80 degrees east and dips 17 degrees to the south. The bands range in width from 4 inches to 10 feet; those consisting almost entirely of quartz are nearly pure white and those containing a large proportion of garnet and biotite are brownish grey. The quartz diorite gneiss differs from the banded variety in containing less quartz and garnet and more feldspars, biotite, and some hornblende. Although it has a strong foliation parallel to that of the other gneiss, its composition and texture give it a striking resemblance to the quartz diorite of the Coast Range batholith which occupies large areas to the southwest. Dykes of aplite and quartz diorite, similar to the quartz diorite gneiss, all of which are equally strongly foliated, cut the banded gneiss. Dykes of these types cutting the Coast Range batholith are plentiful and their presence at this locality, together with the similarity of the quartz diorite gneiss to the rocks of the batholith, seem to indicate that these gneissic rocks represent a highly metamorphosed contact between the batholith and an older series of sediments. The metamorphism is, however, much more intense and different in character from that so far observed by the writer at any other point on the batholithic contact. The possibility that the gneissic rocks belong to an entirely different and much older series of rocks than the Triassic must not be overlooked.

TRIASSIC

On the flat-topped mountains immediately northwest of the West Homathko valley a thick series of volcanic rocks is interbedded with some thin beds of argillite and lenses of limestone containing fossils of Triassic age. Three other areas of similar volcanic rocks, also older than the batholith, occur within the map-area. No fossils were found in these rocks, but, because of their close lithological similarity to the rocks containing Triassic fossils, they are tentatively correlated with them. They may, however, be Jurassic or Lower Cretaceous. One of these areas extends along Klina Klin river for 13 miles southwest from One Eye lake. Another composes Kappan mountains west and north of Kappan lake; the third lies northwest of Hotnarko and Bella Coola rivers. The volcanic rocks are chiefly tuffs and breccias, but dark green to black flows of andesite, in many places amygdaloidal, also occur. The fragmental rocks are red, purple, black, or green, and the fragments range from microscopic size to blocks 12 feet in length. The fragments consist of volcanic rocks similar to the flows, and of cherty, banded sedimentary rocks of unknown derivation.

Two lots of fossils were collected from the Triassic strata. These were submitted to F. H. McLearn who reports as follows:

"Lot 23. In a limestone in a volcanic series northwest of Bluff lake: *Amusium* sp., *Chlamys* sp., *Isastrea* sp., indicating a Triassic or Jurassic date.

"Lot 22. Near the locality from which lot 23 comes and in the same rock series: *Daonella* sp., *Pecten* sp., indicating a Triassic date."

LOWER CRETACEOUS

Two areas of rocks containing fossils of Lower Cretaceous age were found in the district. A southern area crosses West Homathko valley immediately south of Bluff lake. It extends only a few miles northwest of Homathko river, but for many miles in a southeast direction probably as far as Tatlayoko lake. A northern area extends from Sappi lake in a southwesterly direction as far as 4 miles west of Perkins peak and as far northwest as Klina Klin river. The southern area consists almost entirely of dark brown sandstone, conglomerate, and black shale, and contains little or no volcanic material, whereas the northern area is composed largely of thinly bedded sandstone, black argillite, and, particularly in the vicinity of Perkins peak, a considerable amount of volcanic rock. The strata of the southern area strike about north 20 degrees west and dip southwest, whereas those of the northern area bend around to the west and southwest and dip south, thus apparently forming a southerly plunging syncline. They overlie the Triassic rocks in some places unconformably, but in others apparently conformably or nearly so. They are intruded and to a large extent were absorbed by the granitic rocks of the Coast Range batholith.

Several collections of fossils from the Cretaceous beds were submitted to F. H. McLearn who reports as follows:

"Lots 47, 47A, 47B. Eight miles south of Tatla Lake post office, near Sappi lake, in an argillite series: *Polyptychites* sp. The identification of the ammonite is by S. S. Buckman who reports: 'The specimens are of Lower Cretaceous date which may be stated as Neocomian. But greater exactitude can be obtained: the specimens belong to the genus *Polyptychites* and are, therefore, of Valanginian date. According to recent researches of Dr. Spath this may possibly be even more precisely defined as the Polyptychitan portion of the Valanginian.'

"Lot 21. In a sandstone series 4 miles east of Bluff lake: *Pleuromya* sp., of Lower Cretaceous (?) date.

"Lot 2. Near Tatlayoko lake: *Aucella* sp., Belemnites sp., Lower Cretaceous."

COAST RANGE BATHOLITH

The southwestern part of the area is composed almost entirely of quartz diorite, granodiorite, and other related plutonic rocks, forming the Coast Range batholith. The line of contact between the batholith and the older rocks enters the map-area near the southeast corner, follows an irregular course past Twist lake, passes south of Perkins peak, crosses the main branch of Klina Klin river 13 miles south of One Eye lake, bends northward along the western side of Klina Klin valley, and enters the plateau where it is covered by glacial and stream deposits and Tertiary lava flows. The contact again appears 3 miles north of Precipice camp and follows a westerly course roughly parallel to, and 1 to 3 miles north of, Hotnarko and Bella Coola rivers as far as Burnt Bridge creek, where it again bends sharply northward and passes out of the area. Except for small, isolated areas composed of older rocks the whole of the district southwest of this contact is occupied by the batholith. Only two of these areas were observed, though others probably occur in the unexamined parts. Of the two observed the larger is situated west of Kappan lake and forms Kappan mountains. A much smaller one crosses Hotnarko river 1½ miles above its confluence with the Bella Coola.

The composition of the batholith varies but slightly, except in the vicinity of the contacts with the intruded rocks and larger inclusions. The rock consists chiefly of quartz diorite and granodiorite, composed mainly of quartz, plagioclase ranging from oligoclase to andesine-labradorite, and hornblende. It also contains 2 to 15 per cent of orthoclase and 1 to 12 per cent of biotite, the latter, in most cases, but not in all, increasing in amount with the orthoclase. Along the margins of the batholith and in the vicinity of the large inclusions the composition varies from pink granite to black, hornblende diorite. A band of the latter ½ to ¾ mile wide follows the contact for several miles south of Perkins peak. At a distance of ½ or ¾ mile from the contact the rock grades rather abruptly into light grey quartz diorite. The basic phase consists of nearly equal amounts of labradorite and hornblende, with small amounts of biotite and magnetite. The mountains immediately northwest of Klina Klin river are composed of a moderately fine-grained, slightly porphyritic, pinkish rock, consisting of about 40 per cent andesine, 25 per cent orthoclase, 15 per cent quartz, 10 per cent hornblende, and 5 per cent biotite. Small amounts of tourmaline associated with quartz and epidote are widely distributed through the rocks. Many dykes of aplite and pegmatite cut the rocks, and these also contain small quantities of tourmaline and in one case small particles of allanite.

A large body of diorite and quartz diorite similar to the rocks of the Coast Range batholith lies between Tatlayoko lake and Klina Klin river and is separated from the main batholith by a band of older volcanic and sedimentary rocks 10 to 15 miles in width. Most of the rocks composing this body closely resemble those of the Coast Range batholith; a few are quite different. Augite diorite occurs on the high peaks 7 miles due west of the north end of Tatlayoko lake and is the only augite-bearing plutonic rock so far found in either Tatla-Bella Coola or Chilko Lakes areas. This rock consists essentially of labradorite, augite, and hornblende, with a considerable amount of bright green chlorite and a smaller amount of a strongly pleochroic, parallel extinguishing pink to brownish mineral thought to be manganiferous chlorite. West of these peaks the rocks have the composition of hornblende diorite; to the northeast, they consist of quartz diorite. The quartz diorite 5 miles due south of Tatla hill is metamorphosed in an unusual way. The quartz grains, which constitute about 30 per cent of the rock, are intensely crushed and fractured, the hornblende crystals also are broken into fragments and the feldspars, though unbroken, are highly altered to kaolin and perhaps sericite. The fracturing of the quartz grains renders the rock extremely friable and easily eroded. A small creek has cut a canyon through it 400 feet deep, and along the sides of the canyon the rock has been eroded to form pillars, sharp cones, and pinnacles, some of which are over 100 feet high.

Fresh granitic rocks in the northwestern part of the district carry from 25 to 50 per cent of orthoclase and in this respect differ widely from the other rocks of the Coast Range batholith. They differ also in having a lower percentage of ferromagnesian minerals and are on the whole less decomposed. Porphyritic granite immediately west of Precipice camp contains phenocrysts of orthoclase up to an inch in length. Coarse biotite granite was found near Canoe triangulation station, and quartz monzonite occurs along the trail 6½ miles northeast. The strongly marked difference in composition, texture, and general appearance between these rocks and other rocks of the batholith, as well as their less decomposed character, suggest that they belong to a younger period of intrusion.

The contact of the batholith in the part of the map-area southeast of Klina Klin river follows a sinuous course through a region of great relief. It is well exposed and has been traced in detail over most of its extent. The Triassic and Lower Cretaceous rocks adjacent to the contact on the whole are little metamorphosed. Where metamorphism is marked, as on the flat-topped mountains between Miners Lake valley and the main branch of the Klina Klin, the sediments are converted almost entirely to biotite for distances from the contact ranging up to 100 feet. The manner in which the contact crosses the contours of this part of the map-area indicates that there the contact is nearly vertical, whereas in the northwestern part it appears to be nearly flat. Between Klina Klin river and a point 4 miles north of Precipice camp the batholithic contact traverses a part of the plateau and is covered by Tertiary lava flows. Northwest of this point the contact is again exposed and is very irregular, but there it assumes a nearly horizontal attitude and the batholithic rocks are overlain by older intruded volcanic rocks that appear to be remnants of the roof of the batholith.

The age of the Coast Range batholith is not definitely known. The batholith has been found in several localities to cut the Hazelton formation which contains Middle Jurassic and possibly Upper Jurassic fossils, thus indicating the age of the batholith to be not earlier than Upper Jurassic. In the vicinity of Tatlayoko lake and in Bridge River map-area small batholiths, similar in composition to the Coast Range batholith and situated only a few miles from it, cut rocks containing Lower Cretaceous fossils. In Taseko Lake district what appears to be the main Coast Range batholith cuts a thick series of coarse, fragmental volcanic rocks in which the writer found plant remains, determined by Prof. Edward W. Berry, of Johns Hopkins University, to be of Cretaceous age. In the Bella Coola-Tatla area the main batholith intrudes, at many places, rocks containing fossils of Lower Cretaceous age. This evidence proves that this part, at least, of the batholith is younger than the lowest Cretaceous, and the evidence found in Tatlayoko Lake, Taseko Lake, and Bridge River districts strongly suggests that much of the eastern part of the batholith is of post-basal Lower Cretaceous.

TERTIARY LAVAS

Flat-lying Tertiary lavas outcrop over a considerable part of the map-area north of the Lunos trail, and much of the drift-covered areas in the northeastern part of the district is no doubt underlain by these lavas. Similar rocks extend over a very large part of central British Columbia adjacent to the Tatla-Bella Coola area, and compose to a large extent the Rainbow, Ilgachuz, and Itcha mountains. Three small bodies of fresh lavas thought to be late Tertiary or early Pleistocene in age were found in other parts of the district; one at the base of Kappan mountains on the east side, another in West Homathko valley 2 miles north of Twist lake, and a third several miles north of this on the west side of Middle lake. The lavas of the first two areas are basalt similar to that of most of the Tertiary lavas. The rock occurring at Middle lake, however, is a coarse porphyritic rhyolite.

ECONOMIC GEOLOGY

Only a small amount of prospecting has been done in Tatla-Bella Coola map-area and very little mineral has been found. The only deposits in the district known to the writer are: a deposit of auriferous arsenopyrite situated about 2 miles north of Perkins peak, and a deposit of hematite 1 mile south of Perkins peak.

The gold-arsenic deposit is situated at an elevation of 7,500 feet near the brow of the steep, northward-facing side of the deep valley immediately north of Perkins peak. The deposit is reached by a branch trail from the trail leading from One Eye lake to Perkins peak. The ore-bearing veins occur in a series of sedimentary rocks composed of black argillites, dark brown argillaceous sandstones, and fine, cherty conglomerates overlain conformably by thick beds of coarse volcanic breccia which form the summit of Perkins peak. The strata strike north 60 to 70 degrees east and dip southeast 40 to 45 degrees. Fossils found in the near vicinity of the veins are reported to be of Lower Cretaceous age. The rocks are cut by the Coast Range batholith, the contact of which makes a U-shaped bend around the southwest side of Perkins peak and is 2 miles southeast, 4½ miles southwest, and 1½ miles northwest of the deposits. A small diorite stock less than one-fifth of a mile in diameter, similar to and probably a part of the batholith, outcrops in a small cirque ¾ mile southeast of the deposit.

The mineral is in large quartz veins or silicified zones which strike north and are nearly vertical and, therefore, extend up the steep valley wall. There are two groups of showings which may be referred to as the "east" group and the "tunnel" group situated ¾ mile to the west along the strike of the beds. The "east" showings consist of five large open-cuts exposing several irregular and poorly defined silicified zones 10 to 20 feet wide, in which are small quantities of disseminated arsenopyrite. The showings are quite large, but the amount of contained gold unfortunately is small. The "tunnel" showings consist of several small open-cuts and one small adit 12 feet long driven into the cliff in a southerly direction. In the face and floor of the adit are six irregularly-shaped veins of solid arsenopyrite ranging in width from 4 to 13 inches and totalling about 3½ feet. Gold is not present in commercial quantities. Several silicified zones were examined below the adit, but were found to contain only small amounts of arsenopyrite. They, therefore, probably contain only minute quantities of gold.

A deposit of exceptionally pure hematite occurs in a large cirque on the southeast side of Perkins mountain. It is situated near the bottom of the cirque on the north side at an elevation of 7,500 feet. It is reached by a good trail from One Eye lake or Klina Klin flats, both on the Bella Coola trail. The hematite occurs in a bed of tuff, which, with other types of volcanic rock, is interbedded with Lower Cretaceous sediments. The tuff bed is 10 to 30 feet thick and is, in places, completely replaced by hematite. Small veins of quartz and specularite cut it and adjoining beds. The beds strike south 70 degrees east and dip 20 degrees south. The contact of the batholith is slightly more than 1 mile to the south. The sedimentary and volcanic beds lying between the hematite deposit and the contact of the batholith are thoroughly impregnated with pyrite, and along certain well-developed shear-zones near the iron-bearing tuff the rocks are completely altered to talc and sericite schists containing a large amount of pyrite.

The dip of the beds in the vicinity of the iron-bearing tuff is low and is nearly parallel to the slope of the surface. This causes the iron formation to outcrop over an area about 100 yards square and to appear to be of much greater extent than it actually is. A large amount of hematite "float" scattered over a still larger area tends to further exaggerate the apparent size of the deposit. A tunnel, now caved, driven in a northerly direction, evidently passed through the hematite near the portal, and was continued for a considerable distance through heavily pyritized talc sericite schist.

The hematite bed has been traced along the strike for about 100 yards by a series of large open-cuts and it probably extends much farther. Assuming that it extends an equal distance down the dip, which is quite probable, it is likely that the deposit contains over one hundred thousand tons of exceptionally pure hematite. However, the character of the deposit and the nature of the geological formations enclosing it indicate that it was formed by processes quite different from those which produced the ordinary type of sedimentary iron ore, and would virtually preclude the possibility of its approaching the size of even the smallest of the important sedimentary iron ore deposits. Taking this and the inaccessible situation of the deposit into consideration it is evident that the deposit is of little value at the present time.

As a field for prospecting the Bella Coola-Tatla map-area as a whole cannot be highly recommended. The contact between the Coast Range batholith and the older rocks along which mineralization might be expected to occur is, to a large extent, covered by Tertiary lavas and glacial drift. However, from near McClinchy creek to the southeastern boundary of the area the contact of the batholith with the older rocks is well exposed and at several places along it, as in the vicinity of Perkins peak, there are good indications of mineralization. Some of the more highly altered and pyritized rocks of this part of the area might on careful sampling be found to contain commercial quantities of gold.

The contact between the batholith and older rocks is exposed also for a considerable distance between Kappan mountains and the northwestern boundary of the area, and though none was observed mineral deposits may occur in this vicinity. A short distance north of the map-area promising showings have been found and are now being developed by their owners.

HAT CREEK COAL DEPOSIT, KAMLOOPS DISTRICT, B.C.

By B. R. MacKay

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GENERAL STATEMENT

During the past summer (1925) interest was aroused by press reports that an immense field of hard, high-grade, sub-bituminous coal had been proved by diamond-drilling operations on the upper part of Hat creek, 14 miles west of Ashcroft, in Kamloops Mining division, British Columbia. According to these reports three coal seams measuring 177 feet, 10 feet, and 269 feet in thickness and separated by 26 feet and 18 feet of shales, respectively, had been pierced within a depth of 523 feet. The coal was stated to rank fifth in heat units among all the coals entering the Pacific market, and as the field is readily accessible to the Pacific Great Eastern railway the exploitation of the deposit was widely considered to be a most attractive proposition.

This coal deposit has long been known and in the seventies was examined by Dr. G. M. Dawson, who reported on it in the Geological Survey Report of Progress for 1877-78 and in the Annual Report for 1894. Dr. Dawson described the deposit as an enormous bed of good quality lignite occurring in rocks of Tertiary age. He observed 42 feet of clean coal exposed in an 88-foot section above creek-level. He expressed the opinion that the great thickness of the deposit should render it of some importance at least locally, and that from analogy with the Nicola Valley coal occurrence a fuel of the character of true coal might possibly be found beneath the lignite.

Owing to the renewed interest created in the deposit by the recent development work the writer visited the area with the object of securing additional data pertaining to the extent and character of the deposit.

Four days were spent examining coal outcrops and tunnel sections, collecting channel samples for analyses, and searching the neighbourhood for other outcrops of the coal measures. As the drill-cores had been removed from the field he did not have this help in ascertaining the character and structure of the coal, and for data on these points is largely dependent on the drill logs compiled by the Pacific Great Eastern Railway Company. The writer's thanks are due to Mr. T. Kilpatrick, General Manager of the Pacific Great Eastern Railway Company, and to Mr. E. A. Haggen, for blueprints and other data supplied, and to Mr. A. K. Kollias, Mr. J. D. Galloway, Provincial Mineralogist for British Columbia, and Mr. George Wilkinson, Chief Inspector of Mines, for assistance rendered in the field.

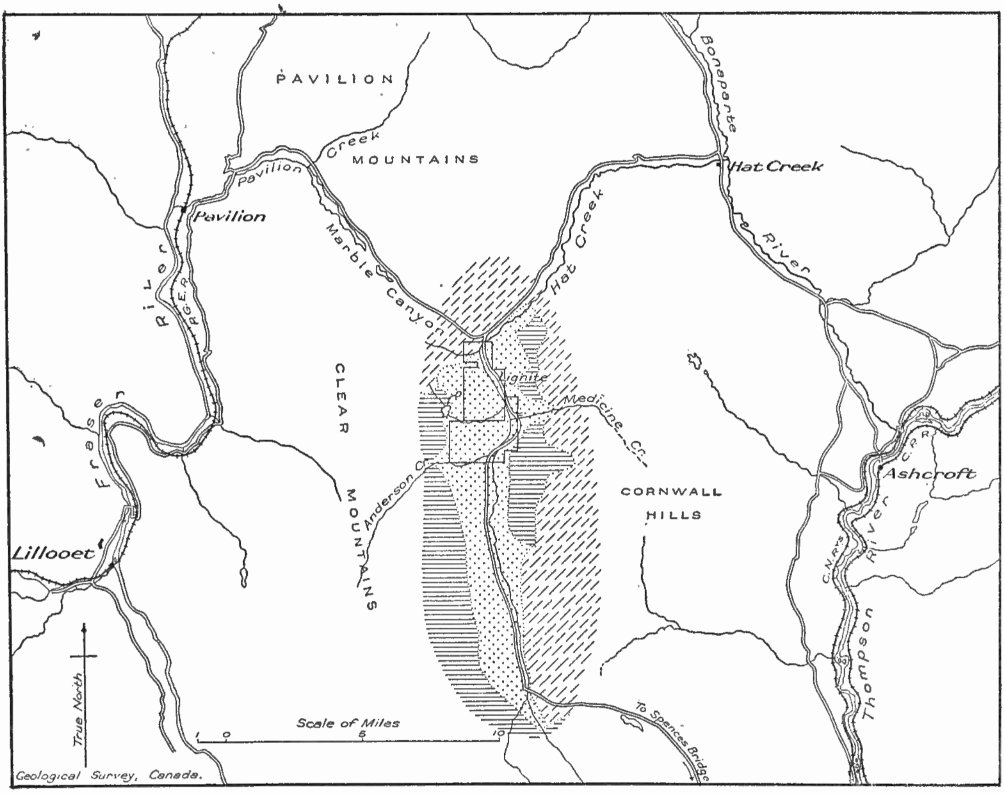

FIGURE 10. Index map showing position and geology of Hat Creek coal area, Kamloops district, B.C. Area occupied by the coal-bearing Tertiary sediments is indicated by stipple, that occupied by Tertiary volcanics by horizontal lines, and that occupied by Carboniferous strata by inclined lines.

LOCATION

The Hat Creek coal deposit is located in the Dominion Railway belt in the Kamloops land recording division, British Columbia (latitude 50° 45', longitude 121° 35'). It lies on the upper part of Hat creek, 15 miles from its junction with Bonaparte river. It is 30 miles distant by road from Ashcroft, on the Canadian National and the Canadian Pacific railways, and 16 miles from Pavilion, on the Pacific Great Eastern railway. The coal field is connected with both these railway centres by excellent motor roads. It is most conveniently reached, however, from Vancouver and outside points via Ashcroft, as the Pacific Great Eastern terminal is at Squamish, on Howe sound. The coal outcrops on the west bank of upper Hat creek a mile above the mouth of Marble canyon, at an approximate altitude of 2,860 feet. Exposures occur at intervals along the stream bank for about 1,500 feet.

GENERAL GEOLOGY

The general geology of Hat Creek area is fully described by Dr. Dawson in his report on the Kamloops map-sheet appearing in the Annual Report of the Geological Survey for 1894, and those interested are referred either to the original report, or to the extracts from it referring to the coal deposits, which appear in Memoir 69.[1] As the writer's examination was confined to the immediate vicinity of the coal deposit only a very brief description of the formations encountered will be given.

The formations occurring in the vicinity of the coal deposit are:

—	—	Formations	Rock types
Quaternary........	Recent..........	....	Stream gravels, landslides, lake deposits, glacial gravels, boulder clay
	Pleistocene.......	....	
Unconformity			
Tertiary..........	Miocene..........	....	Volcanic breccia, basalt breccia, tuffs
	Unconformity		
	Eocene (?)........	Coldwater group..........	Basal conglomerate, semi-indurated sandstone and shales, and coal seams
Unconformity			
Mesozoic(?).......	Jurassic(?)........	Stocks....................	Granite, granodiorite, diorite
Igneous contact			
Palæozoic	Carboniferous.....	Marble Canyon limestone. Cache Creek group	Limestones, argillites, marble

The oldest rock formation exposed near upper Hat creek and the one which apparently underlies all of the coal basin is a thick series of compact, grey limestones and argillites of Carboniferous age. These beds, termed by Dawson the Cache Creek group, have been folded and faulted and 3 miles west of upper Hat creek are intruded by several large stocks of granite, granodiorite, and diorite, so that much of the limestone has been converted into marble, hence the name Marble canyon. The age of the intrusives is not definitely known, but they are thought to be late Jurassic, the period of the Coast Range batholith intrusion.

[1]"Coal Fields of British Columbia"; Geol. Surv., Canada, Mem. 69, pp. 289–294.

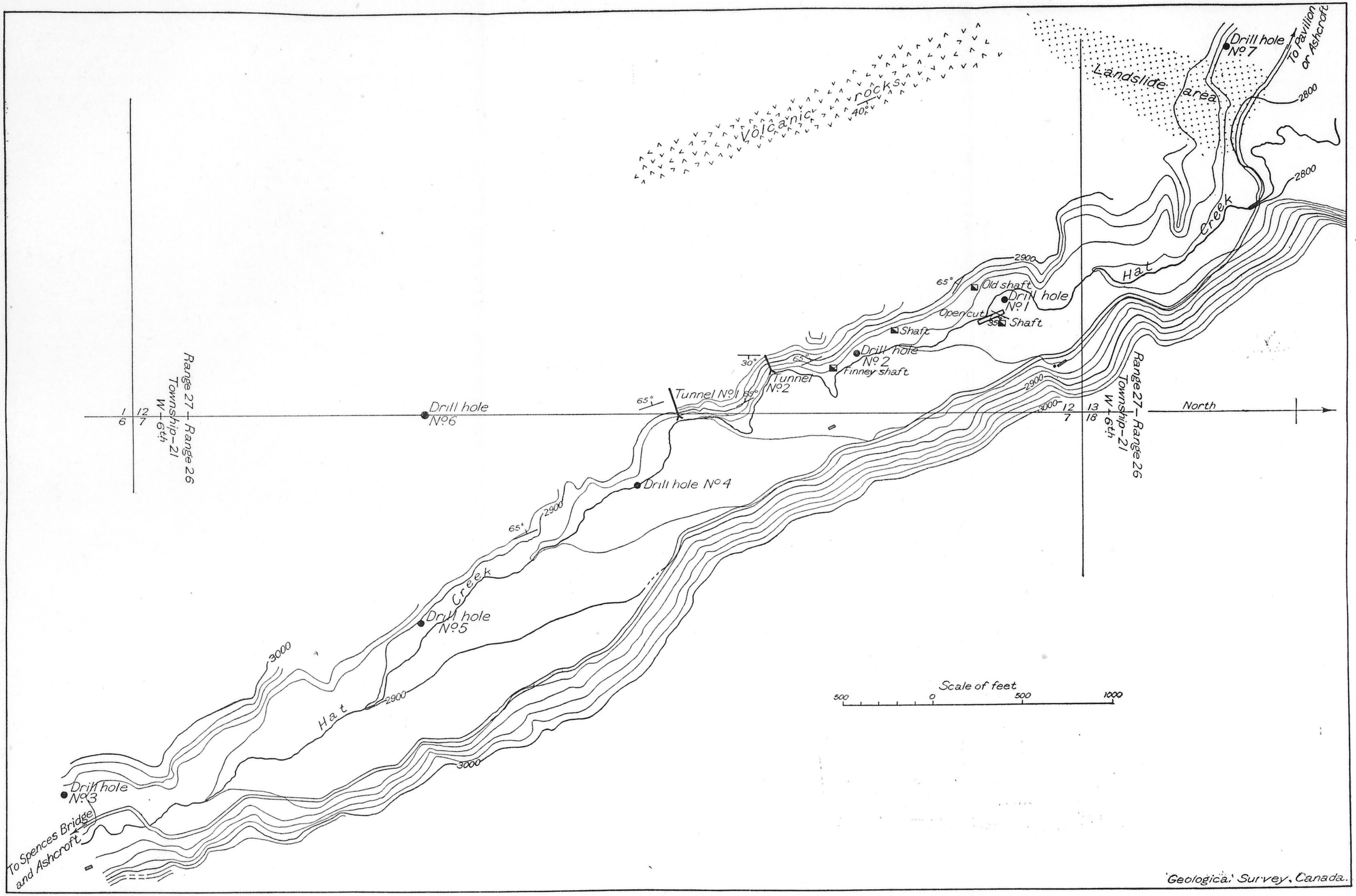

FIGURE 11. Hat Creek coal area, Kamloops district, B.C. Based on a plan prepared by the Department of Railways, British Columbia.

Lying unconformably upon the limestone is a series of early Tertiary deposits, several thousand feet thick, consisting of a basal conglomerate overlain by brown to purplish-weathering, semi-indurated sandstones, shales, and clay, which in the upper part of the series carry thick seams of lignite. The outcrops of these sediments, which have been designated by Dawson the Coldwater group, are confined to the lower slopes of Hat Creek valley, and it may be that the coal basin is very limited in extent. From the divergence of dip observed in the tunnel sections and the volcanic outcrop 1,000 feet distant the Tertiary sediments appear to be unconformably overlain by Miocene volcanics consisting of basalt, breccias, and tuffs, the latter being in places fine-grained and showing distinct stratification, as if laid down under water. These have been subjected to folding and faulting parallel to the general axis of the valley, so that they now dip at angles up to 45 degrees. The volcanics have their greatest development to the west of Hat creek, covering all of Clear Mountain range, where the events were apparently located. Late Tertiary erosion has largely removed the volcanics from the valley area, but remnants of the extensive flows still occur on the east slope of the valley, and on the west of Hat creek close to the coal outcrop.

During the Pleistocene boulder clay and glacial gravels over 100 feet thick were deposited. They cover the valley bottom and extend up the slopes to the height of about 1,000 feet. Much of this is a typical moraine deposit characterized by knob and kettle topography and by numerous small lakes. Later stream erosion has developed a series of terraces along the valley and has exposed the coal measures along the channel of Hat creek; and more recent undermining by the stream has developed in the previous glacial drift a prominent landslip just north of the coal outcrop. The landslip area is characterized by badland topography and small lakes occur in two of the larger depressions.

The economic interest of the area from the mining standpoint centres in the thick deposit of Tertiary lignite. As far as the writer could determine, the coal measures outcrop only in the immediate vicinity of Hat creek. Dawson speaks of soft, yellowish Tertiary shales capped by vesicular lava at the base of Clear Mountain range at an elevation of about 650 feet above the creek-level, but neither this exposure nor a reported occurrence on Finney creek could be found. Tertiary volcanics outcrop 1,100 feet west of the coal exposure on Hat creek at about 200 feet above creek-level and over an area about 300 feet wide by 1,000 feet in length. They strike north 160 degrees east and dip 45 degrees southeast, but owing to the drift mantle their relationship to the coal measures could not be determined. The covering of boulder clay and glacial gravels so completely conceals the bedrock that the boundary of the coal measures cannot be determined with any degree of precision.

DEVELOPMENT WORK

Development work on the deposit began in a small way in 1889, and a drift 18 feet in length was driven into the outcrop. In 1893, a Mr. Finney, a local rancher, acquired title to the land, and sank a shaft near the lower exposure to a depth stated to be 125 feet. The coal had a limited local sale, but with Finney's disappearance the operations ceased and no further attempt appears to have been made until 1923. Then, a Chinese syndicate, having acquired the property, sank three shallow shafts, drove a tunnel 188 feet into the uppermost exposure on the west side of the creek, and made an open-cut about 200 feet in length, 1,800 feet downstream. Two small tipples were erected with the object of shipping the coal by motor truck to the Pacific Great Eastern railway, but operation ceased before this was accomplished owing to the syndicate running out of funds. The Clear Mountain Coal Company, Limited, which was subsequently formed to take over and develop the property, shipped three carloads of the coal, but the marketing of it in Vancouver proved a failure and the company went into bankruptcy. Early in 1925 the property was acquired by the Hat Creek Coal Company, Limited, who drove a second tunnel 105 feet into the same exposure about 600 feet to the north of tunnel No. 1, and opened up a room on its north side 25 feet deep. Later they began a systematic diamond-drilling program to prove up their holdings. In all, seven holes were sunk over a length of 1½ miles, at from 1,400 to 2,000 feet apart and to depths ranging from 60 to 635 feet. Five of these holes were placed along the channel of Hat creek, conforming closely to the strike of the measures, and the remaining two holes were offset about 1,000 feet west of this line. The position of these holes, together with that of the shafts, tunnels, and open-cut are shown on the accompanying plan.

STRUCTURE AND THICKNESS OF DEPOSIT

Nothing is known of the structure of the coal basin except near the outcrop. Along the west bank of Hat creek between drill hole No. 2 and drill hole No. 5 the beds have a uniform strike of north 160 degrees east astronomical and dip westward into the bank at angles of about 65 degrees to 70 degrees. This structure holds throughout tunnel No. 1, with the exception of a narrow fault zone 15 feet from the tunnel entry. In tunnel No. 2 the beds are folded into two synclines which are separated by a compressed and faulted anticline. The axes of these folds strike north 170 degrees east astronomical and plunge 10 degrees south. It was found impossible to correlate the beds in the two tunnels, this being probably due in a large measure to the southward plunge of the folds bringing the beds exposed in No. 2 tunnel, beneath those of No. 1 tunnel.

At the open-cut near No. 1 drill hole the measures strike north 25 degrees east and dip 35 degrees southeast, whereas on the bank 200 feet to the west and 50 feet distant from an old shaft the beds strike north 130 degrees east and dip 65 degrees southwest. This divergence of dip is considered as due to folding and faulting at the northern extremity of the coal basin, similar to that observed in tunnel No. 2.

The deposit proved is exceptionally thick. Tunnel No. 1 pierced 154 feet of beds, of which 108 feet was clean coal, 35 feet was shaly coal, and 12 feet was shale; neither hanging-wall rock nor foot-wall rock was encountered. No. 2 tunnel cut through 76 feet of beds without encountering either wall-rock. Of this, 38 feet was clean coal, 26 feet was shaly coal, and 12 feet was shale and clay. The thicknesses of clean coal, shaly coal, and shale and clay pierced in the several drill holes are shown in the

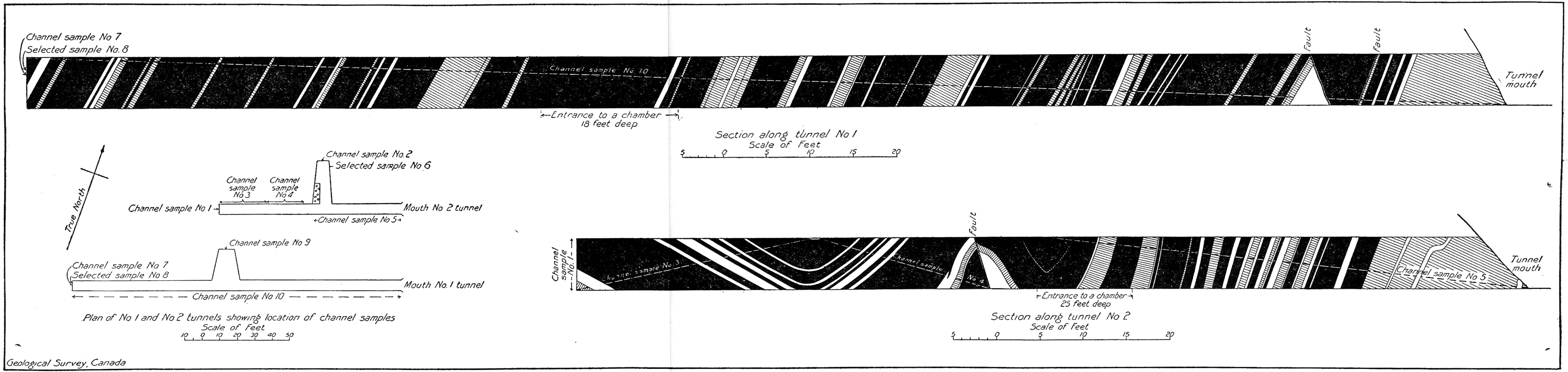

FIGURE 12. Sections along tunnels Nos. 1 and 2, Hat creek, Kamloops district, B.C., showing clean coal (solid black), dirty coal (cross-lined), shale, and other rock (blank).

accompanying tabulated statements compiled from the blueprint of drill logs prepared by the British Columbia Department of Railways. One of these shows a thickness of 269 feet 8 inches of clean coal. Similar detailed sections of the beds observed in tunnels No. 1 and No. 2 are also appended. It is of interest to note the entire absence of sandy beds among those separating the coal.

Section of Beds (in descending order) Penetrated in Bore-hole No. 2

		Feet
Section exposed in cut bank of Hat creek.......	Shaly coal	20
	Shaly coal	26
	Coal	42
	Dirt	3
	Coal	17½
	Shale	½
	Coal	11
	Clay and shale	5
	Coal	23
	Shale	4
	Coal	4
	Shale	3
	Coal	1
	Shale	8
	Coal	6
	Shale	6
	Coal	10
	Shale	2
	Coal	5
	Shale	1
	Coal	2
	Shale	26
	Coal	10
	Shale	18
	Coal	2
	Shale	2
	Coal	3
	Shale	7
	Coal	26
	Shaly coal	6
	Coal	8
	Shale	4
	Coal	211
	Shale	22
	Clay	25
	Sand	35

Assuming strata to dip at an angle of 45 degrees, the true thickness penetrated was 427 feet 8 inches, of which 269 feet 8 inches was coal, 36 feet 9 inches was shaly coal, and 121 feet 3 inches was rock.

Section of Beds (in descending order) Penetrated in Bore-hole No. 4

	Feet	Inches
Boulder and gravel	31	
Shaly coal	80	
Shale	10	
Shaly coal	26	
Clay	2	
Shaly coal	116	
Shale	20	
Coal	20	
Shaly coal	60	
Coal (65% to 75%)	30	
Coal (75%)	13	
Shale	7	
Coal	10	
Shaly coal	20	
Coal	30	

	Feet	Inches
Shaly coal	52	6
Shale	7	6
Shaly coal	60	
Shale	2	
Shaly coal	18	
Shale	20	

Assuming strata to dip at an angle of 60 degrees, the true thickness penetrated was 317 feet 6 inches, of which 30 feet was coal, 237 feet 9 inches was shaly coal, and 49 feet 9 inches was rock. In the bank of Hat creek there is exposed a further section composed of 21 feet of coal, 23 feet of shaly coal, and 88 feet rock. In the bore-hole and bank the combined thickness of coal is 51 feet and of shaly coal 260 feet 9 inches.

Section of Beds (in descending order) Penetrated in Bore-hole No. 5

	Feet
Sand and gravel	10
Boulders	4
Gravel and boulders	13
Shaly coal	15
Coal	3
Shaly coal	28
Coal	3
Shaly coal	30
Shaly coal	24
Coal	3
Broken coal	12
Coal	10
Shaly coal	10
Shaly coal	10
Broken coal	74
Shale	6
No core recovered	10
Shaly coal	10
Shaly coal	30
Ground-up coal dust	10
Shaly coal	20

Assuming strata to dip at an angle of 60 degrees, the true thickness penetrated was 167 feet 6 inches, of which 9 feet 6 inches was coal, 136 feet 6 inches was shaly coal, and 21 feet 6 inches was rock. In the bank of Hat creek there is exposed a further section composed of 21 feet of coal, 23 feet of shaly coal, and 88 feet of rock. In the bore-hole and bank the combined thickness of coal is 30 feet 6 inches and of shaly coal, 159 feet 6 inches.

Section of Beds (in descending order) Penetrated in Bore-hole No. 6

	Feet
Dirt	9
Shaly coal	9
Coal and sand	17
Shaly coal	6
Shaly coal	20
Shaly coal	4
Coal	10
Shale and clay	18
Coal	2
Clay	22
Coal	2
Shaly coal	6
Shale	5
Coal	2
Shaly coal	28
Clay	3
Shaly coal	7
Shale and clay	15
Coal	2
Rock	2
Shale and clay	19
Sandstone	15
Clay	9
Coal	7
Shale and clay	16

	Feet
Coal	15
Shaly coal	10
Shale and clay	9
Coal	3
Shale and clay	10
Coal	25
Shale and clay	12
Coal	15
Clay	2
Coal	8
Shale and clay	6
Coal	6
Shale and clay	14
Clay	18
Coal	7
Coal and clay	7
Shale	9
Coal	13
Shale	4
Coal	56

Assuming strata to be horizontal the total thickness of coal penetrated was 173 feet, and of shaly coal, 97 feet.

Section of Beds (in descending order) in Tunnel No. 1

	Feet	Inches
Coal	1	5
Clay	1	
Coal	1	2
Shaly coal		6
Coal	4	3
Shale		5
Coal		2
Shale		6
Dirty coal		9
Coal	2	
Shaly coal		3
Coal		3
Shaly coal		7
Coal	5	11
Shaly coal		4
Coal	5	0
Dirty coal		4
Coal	4	7
Clay		4
Coal	1	6
Clay		4
Shaly coal		6
Coal	2	11
Shaly coal		3
Coal		5
Shale		4
Coal		10
Shale		5
Coal	4	7
Shaly coal	4	3
Dirty coal		6
Coal	3	9
Dirty coal		6
Coal	15	6
Shale		7
Coal		10
Shaly coal		3
Coal	3	4
Dirty coal		5
Shaly coal	1	6
Clay		5
Shaly coal		11
Dirty coal		8
Coal	4	3

	Feet	Inches
Dirty coal		11
Clay		7
Coal	3	10
Shale		4
Dirty coal	1	4
Shale		2
Coal	1	9
Clay		3
Coal	3	5
Dirty coal		2
Coal	2	7
Dirty coal	3	3
Shale		5
Coal		4
Shale		5
Coal	4	10
Shale		2
Coal		4
Shale		4
Coal	2	8
Dirty coal		6
Coal		3
Shaly coal		5
Coal		3
Shaly coal		4
Coal		5
Shale		2
Coal	1	2
Shale		3
Coal	2	3
Shale		7
Dirty coal	1	
Coal		4
Dirty coal		7
Coal	1	2
Shale		3
Coal		9
Shale		2
Coal		6
Shale		3
Coal	6	6
Dirty coal		5
Coal	3	8
Dirty coal		8
Coal		10
Dirty coal		3
Dirty coal		8
Shale	2	
Fault—of undetermined throw		
Coal	5	
Fault		
Shaly coal		5
Coal	1	
Coal	1	
Shale		4
Shale		4
Coal		7
Shale		6
Shaly coal	11	7
Total thickness	154	11
Total thickness of clean coal	108	1
Total thickness of shaly coal	35	0

Section of Beds (in descending order) in Tunnel No. 2 (disregarding throw in fault)

	Feet	Inches
Clay		6
Coal	3	4
Shale		4

	Feet	Inches
Coal	1	4
Shale		5
Coal		7
Shale		3
Coal		3
Shale		9
Coal		5
Shale		4
Coal	6	0
Clay	1	4
Shaly coal		8
Clay		2
Coal	3	4
Fault—of undetermined throw		
Coal	3	10
Shaly coal		2
Coal	2	10
Clay		2
Shaly coal	2	4
Coal	3	4
Shaly coal	2	
Clay		2
Coal		3
Clay		2
Coal	3	
Dirty coal		4
Coal	1	
Clay		5
Coal	1	
Shaly coal	1	1
Coal	1	0
Clay		5
Coal		10
Clay		3
Dirty coal		9
Clay		3
Coal		8
Clay		7
Dirty coal		4
Clay		2
Coal		3
Clay		11
Dirty coal		10
Clay		1
Coal	1	
Clay		3
Dirty coal		10
Clay		4
Coal		6
Clay		3
Coal	2	6
Clay		10
Coal	2	4
Dirty coal	2	10
Clay		8
Shaly coal	3	
Clay		5
Shaly coal	10	6
Total thickness	72	4
Total thickness of clean coal	37	7
Total thickness of shaly coal	25	3

QUANTITY OF COAL

Although the development work has contributed considerable data on the character, thickness, and structure of the coal deposit, it is not sufficiently advanced to allow of an accurate estimate of the total tonnage of coal present. If the measures lay uniformly over the area exploited, this would be easy of solution, but in their folded and faulted condition, as evidenced in tunnel No. 2 and by the divergence of strike near the open-cut, the problem cannot be solved with the data at hand. Coal was encountered in only four of the seven holes put down, and in one of these (bore-hole No. 6) the writer has no means of determining the strike and dip of the measures. It is unfortunate, also, that bore-hole No. 6, which was terminated in coal, was not deepened sufficiently to prove the thickness of the deposit, or that tunnels Nos. 1 and 2 were not driven far enough to encounter the rock-wall. Moreover, three of these bore-holes lie close to the coal outcrop along the creek, as do the shafts, tunnels, and open-cut, and consequently a much smaller area has been proved than would otherwise have been the case if the advice given long ago by Dawson had been followed. As it is, the area underlain by coal, as determined by the development work, is less than 100 acres, although there is little doubt that many times this acreage of the adjoining territory is coal-bearing. Under the existing conditions the only safe estimate of tonnage that can be advanced is by assuming that the area exploited is underlain by the average thickness of coal as determined in the four drill holes and two tunnel sections. For calculation purposes these are listed below. This is doubtless a minimum estimate.

——	Combined thickness of shaly and clean coal		Thickness of clean coal	
	Ft.	In.	Ft.	In.
No. 2 drill hole and cliff exposure	306	5	269	3
No. 4 drill hole and cliff exposure	311	9	51	0
No. 5 drill hole and cliff exposure	190	0	30	6
No. 6 drill hole and cliff exposure	270	0	173	0
No. 1 tunnel, disregarding throw in fault	143	1	108	1
No. 2 tunnel, disregarding throw in fault	63	3	37	7
	(6) 1,284	6	(6) 669	10
Average thickness	213	1	111	5

Hat Creek lignite has a specific gravity of 1·25 and, therefore, a weight of approximately 1,500 long tons per acre foot. On the assumption that the above average thicknesses underlie the 100 acres, the contained tonnage of coal would be as follows: that of combined shaly and clean coal = 100 (acres) by 213 (feet thickness) by 1,500 (tons per acre foot) = 31,950,000 tons; that of clean coal = 100 (acres) by 112 (feet thickness) by 1,500 (tons per acre foot) = 16,800,000 tons. Most of this tonnage lies below creek-level.

Dr. Dowling estimated the *probable* tonnage of the deposit at 68,000,000 metric tons, assuming an average thickness of 68 feet of coal over an area of 2 square miles. In the absence of outcrops, the extent of the deposit can only be determined by intelligent and systematic drilling. It is highly probable that a considerable part of the coal measures is covered by volcanic flow rock.

QUALITY OF COAL

Hat Creek coal has a dark brown to black colour and a dull, resinous lustre. Hand specimens of the clean coal show alternating layers and lenses of bright and dark material, which range in thickness from microscopic size to several inches. The bright layers represent that part of the coal derived from wood, and the dull portions the parts made up of debris. On drying, the coal breaks with a conchoidal fracture into small, irregular blocks, which on exposure to the weather further disintegrate, yielding very little lump. The coal does not soil the fingers on handling. On firing, it steams and sweats until the excess moisture is driven off, after which it burns with a bright yellow flame. Parts of the coal are characterized by small lenses, globules, and irregular-shaped masses of light yellow, semi-transparent, fossilized amber or retinite. Much of the coal shows highly polished, slickensided surfaces, whereas other parts are made up of small, angular fragments of amorphous coal partly or completely surrounded by a calcareous mud. Much of the coal is thus rendered valueless. Carbonated tree trunks occur in several horizons, and these in some instances have been converted into ironstone.

In sampling the deposit an attempt was made to obtain the average run of coal in the deposit, and the best grade of coal. As no opportunity was afforded the writer to obtain samples from the drill cores, the sampling was confined to tunnel sections. In all, ten samples were taken; eight channel samples and two selected samples. The former were carefully obtained by chiselling a groove, 2 inches in width, across the clean and shaly coal, omitting as far as possible all excessively dirty coal, shale, and clay beds. The resulting sample, amounting in some instances to over 50 pounds weight, was crushed and quartered down to a weight of about 3 pounds. The two selected samples, each in lumps of about 3 pounds weight, were chosen from the faces which appeared to represent the best grade of clean coal in each of the tunnels. All these samples were shipped to the Mines Branch, Department of Mines, Ottawa, in air-tight containers, thus making it possible, as shown in the accompanying tabulation, to have the coal analysed on the three bases: (1) with full moisture content as mined; (2) on an air-dried basis; and (3) on a dry basis. It is now accepted practice to analyse coal with its moisture content as mined, although under normal conditions the consumer will receive a dryer coal. As the writer has made use of all the analyses at his disposal, including both those obtained from the British Columbia Department of Mines and those furnished by the Hat Creek Coal Company, Limited, and as most of these were made on air-dried samples, the air-dried basis is adopted for their tabulation and comparison.

The fifty-eight analyses made use of have been asembled in two groups, one embracing twenty-eight analyses of tunnel samples and the other thirty analyses of drill-core samples, the average analysis of each set and the total average of each group being shown. The final average of the two groups may be considered to represent the true composition of the proven coal. On reference to the table of analyses of tunnel samples and the plate of tunnel sections it may be seen that samples 3, 4, and 5 cover practically the entire length of tunnel No. 2, hence their average analysis, which is also given, should correspond closely with the analyses of sample No. 4 taken by the British Columbia Department of Mines, or the average analysis of tunnel No. 2 full length obtained by that department. The excessively high ash content in Geological Survey sample No. 1 and sample No. 6 of the British Columbia Department of Mines taken at face of No. 2 tunnel is in all probability due to the proximity of the face sampled to the underlying clay bed.

Ten Samples Analysed in the Fuel Testing Laboratory, Mines Branch, Department of Mines, Ottawa

CHANNEL SAMPLES NO. 1 AND NO. 2

—	Sample No. 1			Sample No. 2		
	As received	Air dried	Dry basis	As received	Air dried	Dry basis
Proximate analysis:						
Moisture, per cent	28·2	11·2	....	26·0	15·1	....
Ash, per cent	33·6	41·5	46·7	21·9	25·2	29·7
Volatile matter, per cent	20·7	25·6	28·8	27·3	31·3	36·8
Fixed carbon (by difference), per cent	17·5	21·7	24·5	24·8	28·4	33·5
Sulphur, per cent	0·7	0·9	1·0	0·8	0·9	1·0
Calorific value:						
Calories per gram, gross	2,390	2,960	3,330	3,560	4,080	4,810
B.T.U. per lb., gross	4,300	5,325	6,000	6,400	7,350	8,650
Fuel ratio: fixed carbon: volatile matter	....	....	0·85	....	....	0·91
Coking properties	Non-coking			Non-coking		

Channel sample No. 1 (Laboratory No. 3344) taken across 4-foot face at end of No. 2 tunnel.

Channel sample No. 2 (Laboratory No. 3345) taken across 7-foot face of 25-foot drift north side No. 2 tunnel.

CHANNEL SAMPLES NO. 3 AND NO. 4

—	Sample No. 3			Sample No. 4		
	As received	Air dried	Dry basis	As received	Air dried	Dry basis
Proximate analysis:						
Moisture, per cent	30·4	13·1	....	29·5	13·9	....
Ash, per cent	22·8	28·5	32·8	20·1	24·6	28·5
Volatile matter, per cent	24·2	30·2	34·7	26·8	32·7	38·0
Fixed carbon (by difference)	22·6	28·2	32·5	23·6	28·8	33·5
Sulphur, per cent	1·0	1·2	1·4	1·0	1·2	1·4
Calorific value:						
Calories per gram, gross	3,115	3,885	4,470	3,400	4,150	4,820
B.T.U. per lb., gross	5,605	6,990	8,050	6,120	7,470	8,670
Fuel ratio:						
Fixed carbon: volatile matter	....	....	0·93	....	....	0·88

Channel sample No. 3 (Laboratory No. 3346) across measures in No. 2 tunnel from centre of syncline 75 feet from mouth, to end of tunnel, 105 feet from mouth.

Channel sample No. 4 (Laboratory No. 3347) from centre of syncline in No. 2 tunnel 75 feet from tunnel mouth to centre of anticline 57 feet from mouth.

CHANNEL SAMPLE NO. 5 AND SELECTED SAMPLE NO. 6

—	Sample No. 5			Sample No. 6		
	As received	Air dried	Dry basis	As received	Air dried	Dry basis
Proximate analysis:						
Moisture, per cent	24·8	16·2	....	26·1	17·3	....
Ash, per cent	15·8	17·6	21·0	10·6	11·9	14·3
Volatile matter, per cent	29·7	33·1	39·5	31·5	35·3	42·7
Fixed carbon (by difference), per cent	29·7	33·1	39·5	31·8	35·5	43·0
Sulphur, per cent	0·8	0·9	1·1	0·6	0·7	0·8
Calorific value:						
Calories per gram, gross	3,990	4,440	5,300	4,480	5,015	6,060
B.T.U. per lb., gross	7,180	7,990	9,540	8,060	9,030	10,910
Fuel ratio:						
Fixed carbon: volatile matter	....	....	1·00	....	....	1·00
Coking properties	Non-coking			Non-coking		

Channel sample No. 5 (Laboratory No. 3348) coal seam from centre of syncline in No. 2 tunnel, 50 feet from entry to mouth.

Selected sample No. 6 (Laboratory No. 3349) choicest coal found in No. 2 tunnel, taken in drift on north side of tunnel 45 feet in from mouth.

CHANNEL SAMPLE NO. 7 AND SELECTED SAMPLE NO. 8

—	Sample No. 7			Sample No. 8		
	As received	Air dried	Dry basis	As received	Air dried	Dry basis
Proximate analysis:						
Moisture, per cent	34·2	18·5	....	39·4	18·3	....
Ash, per cent	10·9	13·5	16·6	3·2	4·3	5·2
Volatile matter, per cent	24·2	30·0	36·8	24·7	33·3	40·8
Fixed carbon (by difference), per cent	30·7	38·0	46·6	32·7	44·1	54·0
Sulphur, per cent	0·9	1·1	1·4	0·5	0·7	0·9
Calorific value:						
Calories per gram, gross	3,670	4,540	5,580	3,930	5,310	6,495
B.T.U. per lb., gross	6,600	8,180	10,040	7,080	9,600	11,690
Fuel ratio:						
Fixed carbon: volatile matter	....	....	1·25	....	....	1·30
Coking properties	Non-coking			Non-coking		

Channel sample No. 7 (Laboratory No. 3350) taken across 7-foot face of No. 1 tunnel 168 feet from mouth.

Selected sample No. 8 (Laboratory No. 3351), choicest coal found in No. 1 tunnel, taken at face of workings 168 feet from mouth of tunnel.

CHANNEL SAMPLES NOS. 9 AND 10

—	Sample No. 9			Sample No. 10		
	As received	Air dried	Dry basis	As received	Air dried	Dry basis
Proximate analysis:						
Moisture, per cent	29·6	17·0	....	26·2	15·9	....
Ash, per cent	15·5	18·3	22·1	21·3	24·3	28·9
Volatile matter, per cent	26·5	31·2	37·6	26·2	29·8	35·5
Fixed carbon (by difference), per cent	28·4	33·5	40·3	26·3	30·0	35·6
Sulphur, per cent	0·4	0·5	0·6	0·5	0·6	0·7
Calorific value:						
Calories per gram, gross	3,740	4,410	5,315	3,500	3,980	4,730
B.T.U. per lb., gross	6,730	7,940	9,570	6,290	7,170	8,520
Fuel ratio:						
Fixed carbon: volatile matter	....	....	1·05	....	....	1·00
Coking properties	Non-coking			Non-coking		

Channel sample No. 9 (Laboratory No. 3352) across 9-foot face of 18-foot drift run in on north side of No. 1 tunnel.

Channel sample No. 10 (Laboratory No. 3353) along No. 1 tunnel from mouth to face 168 feet distant.

Twenty-five Analyses of Hat Creek Coal made by D. E. Whittaker, British Columbia Provincial Government Assayer, including Twenty-three Bore-hole Cores and Two Tunnel Averages

—	—	Moisture	Volatile combustible matter	Fixed carbon	Ash	B.T.U.
		Per cent	Per cent	Per cent	Per cent	
No. 1	No. 2 bore-hole, 104 feet deep	20·5	32·5	44·7	2·3	9,765
No. 2	No. 2 bore-hole, 145 feet deep	18·6	26·4	35·7	19·3	7,440
No. 3	No. 2 bore-hole, 250 feet deep	20·0	27·5	41·3	11·2	....
No. 4	No. 2 bore-hole, 305 feet deep	18·5	32·8	40·3	8·4	....
No. 5	No. 2 bore-hole, 350 feet deep	19·7	31·3	41·9	7·1	....
No. 6	No. 2 bore-hole, 400 feet deep	19·5	30·5	42·4	7·6	....
No. 7	No. 4 bore-hole, 50 feet deep	20·2	32·2	39·3	8·3	....
No. 8	No. 4 bore-hole, 89 feet deep	18·0	33·5	41·5	7·0	....
No. 9	No. 4 bore-hole, 125 feet deep	20·9	30·1	39·1	9·9	....
No. 10	No. 4 bore-hole, 175 feet deep	20·1	31·9	39·9	8·1	....
No. 11	No. 4 bore-hole, 240 feet deep	18·4	30·1	37·4	14·1	....
No. 12	No. 4 bore-hole, 290 feet deep	20·9	31·1	39·3	8·7	....
No. 13	No. 4 bore-hole, 340 feet deep	19·2	28·3	37·8	14·7	8,370
No. 14	No. 4 bore-hole, 385 feet deep	20·0	29·7	41·7	8·6	....
No. 15	No. 4 bore-hole, 445 feet deep	19·0	30·5	41·4	9·1	....
No. 16	No. 4 bore-hole, 490 feet deep	15·0	30·8	41·1	13·1	....
No. 17	No. 4 bore-hole, 530 feet deep	20·0	31·9	42·1	16·0	9,222
No. 18	No. 4 bore-hole, 560 feet deep	20·9	29·0	41·4	8·7	....
No. 19	No. 5 bore-hole, 65 feet deep	17·4	32·7	38·8	11·1	....
No. 20	No. 5 bore-hole, 132 feet deep	15·3	33·8	38·8	12·1	....
No. 21	No. 5 bore-hole, 184 feet deep	19·2	32·1	46·7	2·0	9,780
No. 22	No. 5 bore-hole, 240 feet deep	17·1	31·0	42·8	9·1	....
No. 23	No. 5 bore-hole, 305 feet deep	16·8	27·2	31·9	24·1	7,100
No. 24	Average taken from full length of old No. 1 tunnel	19·3	32·3	37·0	11·4	8,420
No. 25	Average taken from full length of new No. 2 tunnel	14·4	31·0	34·5	20·1	7,900
Average of above twenty-five analyses		18·2	30·4	41·2	10·2	8,499[1]

[1]Average of eight B.T.U. analyses

COAL ANALYSES SUPPLIED BY HAT CREEK COAL COMPANY

(Analyses by G. S. Eldridge and Company, Consulting Engineers, Vancouver)

—	—	S	Moisture	Volatile matter	Fixed carbon	Ash	B.T.U.
May 13	Sample 18 feet (evidently refers to distance from portal No. 1 tunnel)....	0·51	16·30	33·73	39·89	10·08	10,600
	Sample 45 feet (evidently refers to distance from portal No. 1 tunnel?)....	0·56	16·12	33·76	38·18	11·94	10,360
May 15	Sample, evidently from No. 1 tunnel............	....	12·25	35·84	41·17	10·74	....
May 19	Sample No. 2 drill hole, depth 309 feet..........	0·30	7·19	40·85	44·12	7·84	11,900
May 26	Sample air-dried basis....	0·44	8·52	43·30	44·18	4·00	12,240
June 17	Tunnel sample—air-dried basis..................	....	13·38	28·42	40·58	17·62	....
June 30	Sample No. 4 drill hole, 330 feet depth, air-dried basis..................	0·27	9·74	38·82	46·40	5·04	11,830
	Sample No. 4 drill hole, 470 feet depth, air-dried basis..................	0·35	9·17	38·83	44·46	7·54	11,480
	Average of above eight analyses..............	0·40	11·58	36·69	42·24	9·35	11,401

(Analyses by Macdonald and MacDonald, Inspecting and Testing Engineers, Vancouver)

Aug. 17	Sample No. 4, 340-foot size, 4½ in. by 1$\frac{21}{32}$ in. (apparently drill hole No. 4, depth 340 feet). Moisture as received 17·95..................	....	8·24	39·06	40·15	12·55	12,195
	Sample No. 2, 104-foot size, 5¼ in. by 1⅝ in. (apparently drill hole No. 2, depth 104 feet). Moisture as received 18·61..................	....	8·79	41·65	41·22	8·34	12,214
	Average of above two analyses..............	....	8·51	40·35	40·68	10·45	12,204

(Analyses by J. R. Williams, Provincial Assayer, Vancouver)

Sept. 18	Sample lignite—drill core.	....	18·00	33·05	38·15	10·80	9,100

A specimen of Hat Creek lignite collected in 1877 by Dr. G. M. Dawson and analysed by Dr. B. J. Harrington gave the following:

—	Moisture	Vol. mat.	Fix. carb.	Ash
By slow coking....................................	8·6	35·31	46·84	9·05
By fast coking....................................	8·6	41·42	40·93	9·05

The calorific value of the coal was not determined.

On comparison it will be noted that the moisture content as determined by Harrington is just about half the average moisture content of the fifty-eight analyses of air-dried samples. The logical inference is that Dawson's specimen had become super-dried while in the office before being submitted for analysis. Otherwise the analysis compares closely with that of the two selected specimens taken by the writer from the face of tunnel No. 1 and from the room off tunnel No. 2, which are considered to represent the best grade of coal in the deposit.

CLASSIFICATION OF HAT CREEK COAL

The average chemical composition and heat value of Hat Creek coal, together with its physical characteristics, determine it to be a lignite. Apparently on the basis of fuel ratio (quotient of fixed carbon divided by the volatile matter of the proximate analysis) and the low moisture content determined by Harrington, Dowling rated Hat Creek coal, in Memoir 59, "Coal Fields of Canada," as of sub-bituminous rank. In classifying low rank coals, however, fuel ratio is not the determining factor, and physical criteria must be taken into consideration along with chemical composition, whereas the moisture content as determined by Harrington is without doubt excessively low. In regard to its heat value, its high moisture content, and its physical appearance, Hat Creek coal differs materially from any of the typical black, shiny, sub-bituminous coals of western Alberta and resembles much more closely the dull lignite coals of the central part of that province. On an ash-free and moisture-free basis it compares quite favourably in chemical composition and heat value with the Drumheller lignite and is superior to the Edmonton lignite, but it is decidedly inferior to both the Drumheller and Edmonton lignites in its greater percentage of ash, its high moisture content as mined, and in its rapid loss of moisture on air drying. In this respect it lies between the Edmonton lignite and that of Souris river, Saskatchewan. The rapid loss of moisture on air drying causes the coal to shrink, crack, and rapidly fall to pieces, leaving very little lump.

COMMERCIAL POSSIBILITIES

The high moisture and ash content and the corresponding low heat value of Hat Creek lignite, together with its non-coking character, makes it wholly unsuitable in its present form for locomotive use and limits its present market to that of a domestic fuel or possibly of a fuel for use in stationary power plants. The great distance of the deposit from a market and the consequent large degradational loss in transit and storage considerably reduces the possibility of the lignite competing successfully in the unprepared state with the higher grade coals of the Pacific coast. An unsuccessful attempt was made in 1924 to market the coal in Vancouver. It is also doubtful whether the coal in the briquetted form could compete successfully, considering the additional charge necessary through preparing the coal for market. The problems to be solved in marketing the coal are similar to those confronting the Saskatchewan lignite industry and should receive careful consideration before any large expenditure of funds in opening up the deposit is warranted.

Should a market for the coal be obtained that part of the deposit in close proximity to the creek apparently could be most economically mined by stripping off the overburden and excavating the coal from the surface downward by the open-cut method, as is being carried on at Sterco, Alberta, where up to 20 feet of overburden is being removed. This method will involve, in addition to the removal and the disposal of the gravel overburden, the handling of a large tonnage of shale, clay, and dirty coal along with the clean coal, and its separation by crushing, screening, and washing. As most of the coal lies below creek-level, the drainage of the pit would be an important factor in determining the depth the deposit could be economically worked. The distance from the creek at which the deposit can be economically mined by the open-cut method will be determined by the thickness of the drift mantle. Beyond where the overburden exceeds 20 feet in thickness, or is covered by the volcanics, the deposit will be best mined by the room and pillar method.

PRELIMINARY REPORT ON SLOCAN MINING AREA, B.C.

By C. E. Cairnes

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INTRODUCTION

Slocan mining area occupies a rectangular strip of territory about 280 square miles in extent between Slocan and Kootenay lakes, West Kootenay district, British Columbia.[1] It includes parts of Slocan and Ainsworth mining divisions and falls within the Selkirk Mountain system of the Cordillera. The area is traversed from east to west by an important valley occupied by Kaslo creek flowing east into Kootenay lake and by Seaton and Carpenter creeks draining west into Slocan lake. New Denver at the mouth of Carpenter creek and Kaslo at the mouth of Kaslo creek are the two largest towns in the area and are connected by boat and rail with Canadian Pacific railway and steamship lines. Important mining centres in the area are grouped about the towns of Sandon and Silverton and the Whitewater property at Retallack. The Kaslo-Carpenter Creeks valley separates the southern Lardeau mountains on the north from Slocan mountains on the south. The relief ranges from 1,730 feet, the elevation of Slocan lake, to over 8,600 feet at the summit of mount Carlyle, the highest peak in the area. Small mountain glaciers occur near the summit of mount Carlyle and Reco mountain. The area, owing partly to forest fires and early lumbering operations, is sparingly forested and has been rendered easily accessible at all points by a network of roads and trails.

As above outlined the area includes one of the oldest, most carefully prospected, and most productive of the lode-mining centres in British Columbia. Since the first discovery of mineral wealth in 1891 the area has produced to the end of 1924 over 38,000,000 ounces silver; nearly 300,000,000 pounds lead; nearly 122,000,000 pounds zinc; a few thousand ounces of gold; and a few thousand pounds of copper. The total valuation of this production may be roughly estimated at about $46,150,000. As compared with the total production of lode mines in the province this area has produced over one-third of the silver, over one-fifth of the lead, and nearly a quarter of the zinc. During the course of its thirty-five years' history some one hundred and forty-three properties have at one time or another shipped ore. Of these, many have long since been abandoned; others are regarded

[1] *See* Geol. Surv., Canada, Sandon Topographical Sheet, Map 1641.

as of potential value, although little has been done on them for a number of years; and still others have been incorporated with other adjacent or nearby properties and their original identity lost under new names and different managements. Twenty-nine properties in the area have made ore shipments in from ten to twenty-nine different years. Many of the twenty-nine properties are among the earliest discovered and are still counted as being among the more important producers of the area. Whitewater mine has a record of twenty-nine producing years, of which the years 1900-24 represent one continuous period of production. The Slocan Star-Silversmith, Ruth-Hope, and Rambler-Cariboo mines have each a record of twenty-eight producing years. The Standard mine, the largest producer in the area, has a continuous record of production from 1905 to the present. The area included at the peak of its production in 1918 some thirty-six shipping mines, of which nineteen shipped over 100 tons. The total production for 1918 alone is valued at about $3,450,000. In 1924 there were, in all, twenty-six properties in the area that during the year shipped ore with an estimated total value of about $1,387,300, represented by $645,435 for silver, $432,380 for lead, and $309,485 for zinc content.

In spite of its evident importance this area has received comparatively little attention in reports hitherto published by the Geological Survey. The unfortunate deaths of O. E. LeRoy and C. W. Drysdale, after investigations extending, with intervals, over a period of nine years, beginning in 1908, precluded publication of the exhaustive report which they had under preparation. In 1917[1] and again in 1919[2] M. F. Bancroft visited the area, but directed his attention chiefly to the eastern section. The investigations at present being undertaken are for the purpose of reviewing and bringing up to date the work previously done in this area and as soon as possible thereafter it is proposed to publish a memoir including a full account of the history, geology, and mineral deposits of the area, the memoir to be accompanied by a geological map.

The following bibliography includes all reports published by the Geological Survey dealing in part or entirely with problems of the Slocan mining area. It also includes a list of miscellaneous papers on subjects relating to the ore deposits of Slocan district.

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The present preliminary report proposes to cover in a general way the progress, particularly of the past ten or fifteen years, in mining in the area; to include some notes of interest on present producing properties; and to offer a brief discussion of some of the problems peculiar to mining conditions in the area.

The writer is grateful for the cordial assistance of the people of Slocan district, particularly the mine owners and managers, without whose valuable co-operation the numerous examinations underground could not have been undertaken. In the field work the writer was most ably assisted by Messrs. W. E. Chantler, E. B. Gillanders, and J. G. Pearcey, all of whom performed their duties in an efficient and enthusiastic manner.

MINING PROGRESS

Slocan mining area includes only a part of what is popularly known as "Slocan district." The latter may be said to include Slocan, Slocan City, and Ainsworth mining divisions, of which only parts of Slocan and Ainsworth divisions are included in the area under present more particular consideration. This area, however, embraces most of the more important mining centres of the district and a discussion of its particular problems applies in a general way to those of the district as a whole.

For thirty-five years the silver, lead, and zinc deposits of Slocan mining area have been attracting widespread attention, both on account of the number and richness of the ore-shoots encountered and the success with which many of these have been worked. In all some one hundred and forty-three properties have at one time or another shipped ore from this area and, in addition, there are many other properties and prospects that have not yet reached the point of production.

Aside from the question of ore reserves and sudden increases in production of different properties from time to time, incidental upon the finding of new ore-shoots, the production of this area, as of Slocan district as a whole, has been influenced in a marked degree by two factors—the market values of the metal produced and the evolution of a successful process for the treatment of its complex ores. The fact that after twenty years of production Slocan district could, beginning in 1912 and for seven years thereafter, suddenly increase its output from a previous yearly average of about 45,000 tons to one of over 180,000 tons, is a fitting tribute to the ability of the district to respond to the great demand for, and increased market price of, its metals during these years. In the same way the great depression in the metal market in 1921 resulted in the lowest production from this area since the earliest years of its history. Except for 1921 the average yearly production since the period of the war has, however, been considerably greater than the average pre-war production and during the last year or so there has been evidence of an increasing interest in Slocan district, supported by a readier influx not only of American but of Canadian capital. Isolated properties are being grouped together under capable management and developments on a large scale are under consideration.

The following table[1], covering the period from 1910 to 1924, shows a distinct relation between the price of metals, the tonnage of ore shipped, and the number of mines operating in Slocan district.

Year	Silver	Lead	Zinc	A	B	C
1910	53·5	4·446	5·520	33	16	66,316
1911	53·3	4·420	5·758	27	10	46,137
1912	60·8	4·471	6·943	34	16	136,370
1913	57·8	4·370	5·648	44	20	208,681
1914	54·8	3·862	5·213	37	16	170,951
1915	49·68	4·673	13·230	45	17	166,922
1916	65·66	6·858	12·804	52	22	201,727
1917	81·42	8·787	8·901	51	25	232,376
1918	96·77	7·413	8·159	63	27	187,637
1919	111·12	5·759	7·338	55	30	169,981
1920	100·90	7·957	7·900	52	23	77,981
1921	62·65	4·545	4·650	37	13	11,215
1922	67·53	5·734	5·716	49	12	51,719
1923	64·87	7·267	6·438	44	10	76,297
1924	66·78	8·097	6·344	40	16	73,533

Market quotations represent average New York prices for these years.
A—number of shipping mines. B—number of mines shipping over 100 tons. C—total tonnage.

[1]Table compiled from reports of the B.C. Minister of Mines for these years.

The importance of zinc ore in the past ten years or more has exerted a very considerable influence on the production and prosperity of Slocan district. Most of the silver-lead properties contain more or less zinc and its presence was for many years a great disadvantage to the ores. Until a selective flotation process was introduced it was impossible to make an effective separation of the zinc from the lead ore and at the same time secure a desirably high recovery of the contents. Hand-sorted lead ores commonly contained an objectionable proportion of zinc mineral. Smelters exacted a severe penalty in proportion to this zinc content, with the result that many properties of present importance were then considered worthless. The present treatment of these complex lead-zinc ores by selective flotation enables the producer to separate the zinc from the lead with a minimum of loss and maximum of concentration. Improvements in the metallurgy of zinc ores also allow for their successful treatment by the smelters and the zinc metal so produced commands a high market price. Of the one hundred and forty-three properties in Slocan mining area thirty have shipped more or less zinc ore. The relative importance of these thirty properties is brought out in the following tables.

The total production of the area until the end of 1924 is, in round numbers,[1] as follows:

Tonnage	1,793,000 tons
Silver	38,140,000 ounces
Lead	299,320,000 pounds
Zinc	121,850,000 pounds

The total production of the thirty zinc-producing properties is, approximately:

Silver	31,300,000 ounces
Lead	250,400,000 pounds
Zinc	121,850,000 pounds

These figures bring out three points of interest, namely, that the bulk of the ore from this area is obtained from a comparatively small proportion of the properties; that these outstanding properties carry important values in zinc as well as in silver and lead; and that, on a basis of valuation, the returns from either silver or lead production have, so far, been much in excess of that of zinc.

The silver and lead production of the thirty zinc properties during the period when zinc ore was shipped, is as follows:

Silver	15,970,000 ounces
Lead	122,480,000 pounds
Zinc	121,850,000 pounds

These figures are interesting as they show that during the years of zinc production the amount of zinc metal recovered from shipments was, even under a prevailing high market price, hardly as great as that of lead. The value of the silver production for the same years and from the same properties was much greater than either the lead or zinc, and in this connexion it should be remembered that the greater part of the silver values are associated with the lead rather than the zinc ores.

[1]These figures represent the totals as far as information is available. They are, however, somewhat less than the true totals should be, as in the earlier years of shipments the figures of production were, for a few properties, not obtainable in certain years.

The following table, based on returns submitted annually to the provincial government from the various mining properties, represents the production of the Slocan mining area during the years 1915 to 1924, inclusive. All properties of which the writer has any knowledge are included, the table showing the different years on which shipments were made from each of these properties, the total tonnage mined[1] during their years of production, the approximate total value of the combined silver, lead, and zinc content of this tonnage, and the relative importance of the three metals concerned. The figures for "value" are not strictly accurate, as they are based on the average market price for the year rather than the price prevailing at the particular time of the year at which shipments were made. In other respects, too, these figures are subject to some revision, but, on the whole, they are regarded as expressing, as far as data are at present available, a closely approximate idea of production in the area during these ten years. In calculating the value of this production the average New York market prices for each shipping year have been used as a basis, and for silver 95 per cent, for lead 90 per cent, and for zinc 85 per cent, of such prices have been taken. No deductions have been made for treatment or other charges.

List of Properties Shipping Ore, 1915-24

Property	Years in which shipments were made										Tonnage	Value	Order of importance
	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924			
Alamo Mill	....	....	....	....	x	....	....	....	....	....	14,847	$ 142,052 28	Ag Zn Pb
Alpine	x	....	....	....	....	....	....	....	....	....	4	189 28	Pb Ag
American Boy	....	....	....	....	....	....	....	....	x	....	32	3,527 50	Pb Ag Zn
Antoine	....	....	....	....	....	x	....	....	....	....	6	2,184 22	Ag Pb
[1]Apex	....	x	....	....	....	....	....	....	....	x	58	4,474 08	Ag Pb
Bell	....	x	x	x	....	....	....	....	....	....	1,108	127,254 86	Zn Ag Pb
Best	....	....	....	x	....	....	....	....	....	....	37	5,693 63	Ag Pb
Black Colt	....	....	....	....	x	....	....	x	x	....	38	5,732 30	Ag Pb
Black Grouse	x	x	x	....	....	....	....	....	....	....	23	1,507 99	Ag
Bon Ton	....	....	x	x	x	....	....	....	....	....	13	2,755 71	Ag Pb
[1]Bosun	....	....	....	x	x	x	x	x	x	x	53,717	1,045,481 82	Ag Pb Zn
Buffalo	x	....	....	....	....	....	....	....	....	....	14	6,924 53	Ag Pb
[1]Caledonia	....	....	x	x	....	....	x	x	x	x	32	3,151 36	Pb Ag
[1]Canadian	....	....	....	x	....	x	x	....	x	x	210	16,910 91	Pb Ag
Capella	....	....	....	....	x	....	....	....	....	....	4	1,032 38	Ag
Carnation	....	....	....	....	....	....	....	x	....	....	3	386 80	Ag Pb
Chambers	....	....	....	....	....	....	x	....	....	....	6	649 55	Pb Ag
[1]Charleston	x	....	....	....	....	....	....	....	....	x	39	6,154 15	Ag Pb
Cinderella	....	....	....	....	....	....	....	....	....	x	2	286 07	Pb Ag
Comstock	....	x	....	....	....	x	....	....	....	....	28	3,614 35	Ag Pb
[1]Cork-Province	x	x	x	x	x	....	....	....	x	x	37,878	320,035 39	Pb Ag Zn
Daniel	....	....	x	....	....	....	....	....	....	....	18	1,170 63	Zn Ag
Echo	....	....	x	x	x	....	....	x	....	....	776	106,772 81	Ag Pb Zn
Elkhorn	....	x	....	....	....	....	....	....	x	....	9	563 35	Pb Ag
Flint	....	....	x	....	....	....	....	....	....	....	7	609 54	Pb Ag
Freddie Lee	....	....	x	x	x	....	x	....	....	....	139	25,722 95	Ag Pb
[1]Galena Farm	x	x	x	x	x	....	....	x	x	x	56,835	1,026,469 17	Zn Pb Ag
[2]Gem	....	....	x	x	x	....	x	x	x	....	59	8,459 78	Pb Ag
Grey Copper	....	....	x	....	....	....	....	....	....	....	37	5,216 26	Pb Ag
Hartney Group	....	....	x	....	....	....	....	....	....	....	12	1,691 76	Pb Ag
Helena	x	....	....	....	....	....	....	....	....	....	6	812 09	Ag Pb
[1]Hewitt	x	x	x	x	x	x	....	....	x	x	61,786	783,440 57	Ag Zn Pb

[1]This tonnage was either shipped crude or, where milling facilities permitted, concentrated before shipment.

List of Properties Shipping Ore 1915-24—Continued

Property	Years in which shipments were made										Tonnage	Value	Order of importance
	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924			
Home Rule	x	....	....	....	....	....	....	....	....	....	2	164 44	Pb Ag
Idaho-Alamo	x	x	x	x	x	x	....	x	....	....	1,498	130,829 82	Ag Pb Zn
Ivanhoe	x	x	x	x	x	x	x	....	....	....	3,317	52,523 83	Ag Pb Zn
Last Chance	....	....	....	....	....	x	x	x	....	....	109	12,148 90	Ag Pb
Liberty	....	....	....	....	....	....	....	....	x	....	3	388 05	Pb Ag
Lone Bachelor	....	....	x	....	....	....	....	....	x	....	42	4,455 57	Ag Zn Pb
[1]Lucky Jim	x	x	x	x	x	....	....	....	....	x	24,989	796,486 52	Zn Ag Pb
[1]Lucky Thought	x	x	x	x	....	....	....	....	....	x	3,843	87,973 26	Ag Pb Zn
Majestic and Unexpected	....	x	....	....	....	....	x	x	....	....	14	1,056 11	Pb Ag
[1]Martin	x	x	....	....	....	....	....	....	....	x	59	5,107 00	Pb Ag
McAllister	....	....	....	....	....	x	....	x	....	....	60	18,265 51	Ag Pb
Mercury	x	....	....	....	....	....	....	....	....	....	17	460 18	Ag Pb
Metallic	....	....	....	....	....	....	....	x	x	....	69	5,063 16	Ag Pb
Mohawk	....	....	....	x	....	....	x	....	....	....	6	1,177 81	Ag Pb
Molly Hughes[3]	x	x	....	x	x	x	x	x	x	x	299	38,729 90	Ag Au Pb
[1]Monitor	....	....	....	....	....	....	....	x	x	x	265	17,974 45	Pb Ag Zn
Montezuma	x	....	....	x	....	....	....	....	....	....	207	3,158 38	Zn Pb Ag
[1]Mountain Chief	....	....	....	....	....	....	....	x	x	x	114	10,032 01	Ag Pb Zn
Mountain Con	x	....	....	....	....	....	....	x	....	....	122	46,464 92	Ag Pb
Mowitch	....	....	....	....	x	x	....	....	....	....	45	5,194 28	Ag
Noble Five	....	....	....	....	....	x	....	x	....	....	419	20,653 38	Zn Pb Ag
Noonday (Leadsmith)	....	x	x	....	x	....	....	x	x	....	283	22,387 75	Pb Ag
Number One	....	x	x	x	x	....	....	x	....	....	386	47,921 80	Pb Ag
Ocean	....	....	....	....	x	....	....	....	....	....	3	522 05	Ag Pb
Omega	....	....	....	....	x	....	....	....	....	....	5	712 98	Ag Pb
Panama	x	x	....	....	....	....	....	....	....	....	60	3,607 66	Ag
Payne	....	x	x	x	....	x	....	x	....	....	127	18,253 39	Ag Pb
[1]Queen Bess	....	x	x	x	x	x	x	x	....	x	12,436	1,619,209 37	Ag Pb
Rainbow	....	....	....	....	....	....	....	....	....	x	1	176 26	Pb Ag
[1]Rambler-Cariboo	x	x	x	x	x	x	x	x	x	x	77,838	936,002 03	Ag Pb Zn
Reco	x	x	x	x	x	....	....	....	....	....	264	37,849 07	Ag Pb Zn
Redress	....	....	....	....	....	x	x	....	....	....	8	2,027 14	Ag Pb
Richmond-Eureka	....	x	....	x	x[4]	x	....	....	....	....	105	3,862 53	Ag Pb
Rio	x	....	....	....	....	....	....	....	....	....	13	2,100 40	Ag Pb
[1]Ruth-Hope	x	x	x	x	x	x	x	x	x	x	2,812	276,395 14	Ag Pb Zn
Silver Glance	....	....	....	....	....	x	....	....	....	....	6	187 87	Ag
Silverite	....	....	....	....	x	....	....	....	....	....	49	6,459 87	Ag Pb
Silver King	....	x	....	....	....	....	....	....	....	....	3	435 98	Ag Pb
[1]Slocan Star	x	x	x	x	x	x	x	x	x	x	191,948	3,743,278 69	Ag Pb Zn
Soho	....	....	....	....	....	....	....	....	x	....	33	2,046 60	Ag Pb
[1]Sovereign	....	x	x	x	x	x	....	x	x	x	3,922	94,905 90	Pb Ag
[1]Standard	x	x	x	x	x	x	x	x	x	x	222,787	6,332,948 04	Zn Ag Pb
Sunset-Trade Dollar	....	....	....	x	....	....	....	....	....	....	19	828 23	Ag Pb
[1]Surprise	x	x	x	x	x	x	x	x	x	x	47,168	2,740,649 39	Ag Pb Zn
Ten Day Man	....	....	....	....	x	....	....	....	....	....	16	3,861 70	Ag Pb
Utica	x	x	x	x	x	x	x	x	....	....	3,439	391,926 41	Ag Pb Zn
[1]Van Roi	....	....	x	x	x	x	x	x	x	x	69,735	701,222 22	Ag Zn Pb
Victor	....	....	....	....	....	....	....	....	x	x	100	24,350 83	Ag Pb
Victoria	....	....	x	....	....	....	....	....	....	....	2	180 48	Pb Ag
Wakefield	x	....	....	....	x	....	....	....	....	....	73	8,912 91	Ag Pb
Washington	....	....	....	....	....	x	....	....	x	....	75	9,799 88	Pb Ag
Wellington	x	....	....	....	....	....	....	....	....	....	7	756 05	Ag Pb
[1]Whitewater	x	x	x	x	x	x	x	x	x	x	5,256	500,413 91	Ag Zn Pb
Wonderful	x	x	x	x	x	x	....	x	x	....	20,345	284,705 58	Pb Ag Zn
Yakima	....	x	....	....	....	....	....	....	....	....	22	1,954 77	Ag Pb

[1]Properties marked thus are referred to more fully in a subsequent section of this report.
[2]Placer ore from this property.
[3]Shipments from the Molly Hughes included gold values to the amount of about $3,000.
[4]Shipments in 1919 treated at Alamo mill and not included in figures for this property.

PRESENT PRODUCING PROPERTIES

This section of the report is devoted to a discussion of properties in Slocan mining area that at the time examined were, or had recently been, actively engaged in production. The discussion is necessarily brief and confined to facts regarding the ownership and location of the properties, and to interesting features of the ore deposits rather than to theories as to their origin or future possibilites. A more general discussion of the problems encountered in mining is given in a subsequent section of the report.

APEX AND MOUNTAIN CHIEF

The Apex and Mountain Chief are two separate properties owned by W. J. C. Wakefield and associates of Spokane and located on the south side of Carpenter creek near the New Denver-Sandon road, about 1½ miles from New Denver. Development work on the Apex claim has been confined to a quartz vein running north 70 degrees west and dipping about 40 degrees south. The vein is tapped by a crosscut 485 feet long driven from above the New Denver road. It has been worked on two levels and shows a maximum width of 2 feet or more of solid quartz containing pockets, lenses, and irregular disseminations of ore minerals. The ore is the "dry" type characteristic of those deposits occurring near or in the batholithic rocks of the area. The formation here includes argillaceous and calcareous sediments striking north 40 degrees west and dipping about 45 degrees southwest. These sediments are intruded by large porphyry dykes and by a granitoid stock which occupies a considerable area to the north of Carpenter Creek valley opposite the portal of the crosscut tunnel. Leasers shipped 28 tons of silver ore from this property in 1924. Previous shipments contained some lead, but in small proportion as compared with the silver content.

The Mountain Chief group, including the Mammoth, Mountain Chief, and Egypt claims, was worked extensively between 1892 and 1897. During this period a quantity of high-grade silver-lead ore was shipped, but operations were suspended for a number of years owing, probably, to the marked increase of zinc with depth. In 1921 and the years following development was resumed by leasers who up until the end of 1924 shipped some 114 tons of silver-lead-zinc ore carrying an average of about 70 ounces silver, 11 per cent lead, and 15 per cent zinc. In 1925 a two-compartment jig was erected about 200 feet above the road and, at the time visited, was being operated chiefly for the recovery of zinc ore from the old dumps.

In all there are nine or ten tunnels on this property. Most of them are short, the principal development and production being from the upper three levels where the ore has been stoped to the surface. The vein or veins are irregular in strike, varying from north 40 degrees east in the lower workings to north 65 degrees east in No. 3 level and to north 20 degrees east on the surface. In the lower levels the vein varies up to 4 feet in width and is composed chiefly of quartz containing strips or bands of zinc blende up to 8 or 10 inches wide. In the upper workings the vein matter is less siliceous and, where stoped out, is said to have been composed chiefly of lead ore carrying an increasing proportion of zinc blende with depth. The country rocks include similar types to those occurring on the Apex claim.

BOSUN

The Bosun mine was taken over by the Roseberry-Surprise Mining Company in 1916 and is being operated by them under the management of Mr. J. P. MacFadden, New Denver, B.C. The property, including eight mineral claims covering about 200 acres of mineral land, is located on the east shore of Slocan lake about 1½ miles south of New Denver.

The mine has been developed by six adit tunnels, giving a vertical depth of about 500 feet below the vein outcrops. The portal of the lowest or No. 6 adit is about 50 feet above Slocan lake.

The property was discovered in 1898 and worked until 1906, during which time it produced several thousand tons of silver-lead and silver-zinc ore. Zinc shipments up to February 1904 are said[1] to have totalled 1,440 tons, averaging 71·3 ounces silver, 1·8 per cent lead, and 41·8 per cent zinc. Several shipments of this zinc ore, aggregating 620 tons, were shipped to Antwerp at an original cost of $21 per ton freight, afterwards reduced to $16. Following this period of production the mine lay idle until taken over by the present owners in 1916.

The vein is a fissure striking about north 55 degrees east, dipping to the southeast at an average angle of 50 degrees, and varying in thickness from a few inches to over 5 feet. The pay-streak is much narrower and is composed of galena and sphalerite, associated, in the richer portions of the ore-shoots, with a more or less abundant dissemination of grey copper. The vein is offset to the right at intervals along its course by strong zones of shearing which strike about north 55 degrees west or closely in line with the bedding planes of the enclosing rock. These sheared zones are localized along, or near, what appear to be narrow dykes or sills of rather basic composition. In addition to these larger offsets the course of the vein has proved most difficult to follow by reason of numerous smaller irregularities, the general lack of definition to the foot-wall, and the common occurrence of slips or faults leading off into the hanging-wall. These slips are commonly accompanied by more or less mineralization and are in many places difficult to distinguish from the true vein which on occasion may itself roll in the direction of these slips for considerable distances before assuming its regular course.

The greater part of the ore above the lowest or No. 6 level has already been removed, but no work has been done below this level. The company is at present developing an important shoot of silver-lead-zinc ore above No. 6 lying between 400 and 600 feet of the face. Another high-grade ore-shoot has been encountered along a distance of about 300 feet in No. 6 level between 1,500 and 1,800 feet of the portal. Other showings between this and the portal are worthy of further investigation. Different parties of leasers are engaged in working out the old ore-shoots above No. 5 level.

An interesting cross-section of the formations represented at the Bosun mine is exposed along the shore of Slocan lake to the north of the compressor house. The rocks are mainly sedimentaries composed of massive argillaceous and quartzitic types, including some limestone beds and a large proportion of more or less calcareous strata. These sediments are intersected by a number of dykes varying in width up to 85 feet and

[1]Dept. of Interior, Mines Branch—Rept. of Zinc Commission, 1906, p. 209.

with a strike about that of the bedded rocks. Some of these dykes have a close resemblance in size, position, and composition to those encountered underground.

CALEDONIA

The Caledonia claim, situated at Blaylock station to the east of the mouth of Rossiter creek, is owned by George E. McCready, Kaslo, B.C.

The vein on this claim is a faulted fissure striking a little south of east and dipping to the south at about 75 degrees. It cuts across laminated slaty rocks and several beds of limestone varying from about 3 to 15 feet in thickness. The sediments strike about northwest and southeast and dip to southwest at an average angle of 70 degrees.

The vein is tapped by a crosscut tunnel 140 feet long and has been drifted on for about 60 and 65 feet respectively to the west and east of this crosscut. The principal ore-body is encountered on the north side of the west drift about 10 feet from the crosscut and at the intersection of one of the limestone beds with the vein. A raise driven a few feet east of the crosscut encounters this ore-body about 30 feet above the level, from which point it has been stoped to the surface, a farther distance of about 35 feet. What is probably the same limestone bed is exposed on the surface and is mineralized for 100 feet or more to the northwest of the vein. Faulting along the line of the vein fissure has abruptly terminated both limestone beds and ore in this direction.

The ore has evidently resulted from replacement of limestone and is composed of clean lenses of galena, as well as a more intimate mixture of galena and zinc blende, in a gangue of calcite and siderite with, in places, a little quartz.

CANADIAN GROUP

The Canadian group of five claims, including the Adams, Brandon, Sarah B., Katie D., and Hill Top Fraction, comprises in all 162·18 acres and is located on the summit and north and south slopes of Silver ridge at the head of Ivanhoe basin, 3 miles distance, by road and trail, from Sandon, and between 3,000 and 4,000 feet above it. The group is owned and operated by J. M. Brandon, Silverton, B.C.

The property shipped some 216 tons of silver-lead ore during the years 1904 to 1908. Following this period of production work was discontinued until about 1918, since which time development work has been actively resumed and, up to the end of 1924, some 210 more tons of silver-lead ore shipped.

Most of the development work has been done on two veins known as the Ivanhoe-Canadian and No. 1 vein, respectively, situated near the summit and on the northern slope of the ridge. Other promising vein exposures occur on the south slope, where very little work has yet been done. The Ivanhoe-Canadian vein has been drifted on into Canadian ground (Katie D. claim) from No. 4 and No. 8 levels of the adjoining Ivanhoe property and connected by a raise. No. 1 vein is developed on the Adams claim by three tunnels, including some 1,200 feet of crosscuts and drifts, giving a depth on the vein of about 600 feet below the summit. Two shoots of silver-lead ore were discovered in the upper or No. 1 adit on this No. 1 vein. No. 2 adit has also reached a prominent shoot of mill-feed ore which should be picked up by further drifting on the lowest or No. 3 adit. A recent shipment of 58,907 pounds from No. 1 vein assayed, according to Trail Smelter returns, 123·9 ounces silver, 68·95 per cent lead, and 3·7 per cent zinc per ton, giving a total gross value for silver and lead content of $5,129.60.[1] No. 2 vein, lying some 300 or 400 yards west of No. 1 vein and striking about north 50 degrees east, has been exposed by a line of surface strippings.

CHARLESTON GROUP

The Charleston group, consisting of the Charleston, Keystone Fracture, Kingston, Colorado, and Corean claims, is assessed to the Northern Trust Company of Winnipeg, whose interests are handled by A. J. Harris, Zincton post office, one of the original owners who has been associated with the property for many years. The group is located in the basin of Whitewater creek, within a short distance of the Whitewater mine road and about 2½ miles from Retallack station.

Three well-defined veins are being developed on this property—one each on the Charleston, Keystone, and Colorado claims. These veins strike in a general direction of about north 60 degrees west and dip to the southwest at an average angle of from 50 degrees to 65 degrees. The veins are zones of shearing and fissuring following, or cutting at small angles, the rock formation, which is composed chiefly of black, slaty sediments interbedded with narrow bands of limestone. The veins vary in thickness from a few inches to several feet and contain lenses and shoots of silver-lead-zinc ore from which a small tonnage has been mined, sorted, and shipped. Sphalerite is the most abundant ore mineral and is associated in places with an abundance of grey copper carrying good values in silver. Galena is irregularly distributed through the ore. Quartz and siderite are the chief gangue minerals and the vein filling includes a large proportion of the associated country rock.

Work on the Charleston claim includes over 2,000 feet of tunnelling. The vein has been developed by six adits of which the "Harris tunnel," 800 feet long, situated between Nos. 3 and 4 adits, is the longest and No. 1 the shortest. A shipment of 51,715 pounds of ore on January 31, 1924, is stated to have assayed 0·04 ounce gold, 170·3 ounces silver, 33·45 per cent lead, and 22·2 per cent zinc.

The Keystone vein is developed by two adits about 70 feet apart, vertically. The upper adit is about 150 feet long and has exposed milling ore across a width of from 4 to 4½ feet. This ore is said to average $15 a ton in silver-lead-zinc values. The lower adit is about 300 feet in length, but does not appear to have yet reached the most favourable ground.

Development on the Colorado claim includes about 300 feet of tunnelling. The vein was intersected near the portal and has been drifted on near the face. Very little ore mineral was noted, but specimens showing an abundance of grey copper were obtained from the dump at the portal.

CORK-PROVINCE

The Cork-Province mine is owned and operated by Cork-Province Mines, Limited. J. Zwicky, Kaslo, B.C., is manager and W. H. Burgess, Kaslo, B.C., is secretary.

[1]From report on property by J. M. Brandon.

The property includes thirteen claims and is situated on the east side of Mansfield (south fork of Kaslo) creek at a distance of 9 miles from Kaslo and 4½ miles from Zwicky station (Nashton post office). A good road leads from Kaslo to the mine, which lies at an elevation of about 1,600 feet above Kootenay lake.

The ore-bodies of the Cork-Province mine occur where a well-defined vein, striking about north 50 degrees east and dipping to the southeast at an average angle of 65 degrees, intersects beds of crystalline limestone striking north 65 degrees east and dipping from 75 degrees to 85 degrees southeast. The limestone is interbedded with more or less metamorphosed and argillaceous sediments and forms beds up to about 90 feet in thickness. Three of these beds have been encountered in the underground workings and have developed ore at the vein intersections. A fourth has not yet been reached by the easterly extension of the drift on the vein in No. 3 level. The vein is a fissured and sheared zone, averaging from 5 to 6 feet in width, in which the hanging-wall side has dropped with respect to the foot-wall and thereby offset the limestone beds in each case about 80 feet to the west.

The vein filling consists chiefly of altered limestone and siderite with some quartz and calcite. Galena and zinc blende are the important ore minerals, but subordinate amounts of pyrite and chalcopyrite are also present. In general the vein is sparsely mineralized, but important ore-shoots occur where the limestone beds have been intersected. The vein at these intersections is much enlarged, since the ore replaces the limestones for distances up to 100 feet from the vein on the hanging-wall side. On the foot-wall side the concentration of ore minerals is less noticeable.

The mine is developed by three adit tunnels, giving a vertical depth of about 400 feet below the surface. No. 3 adit is on the level of the mill and represents the lowest tunnel site that can be obtained. It reaches the vein by a crosscut 930 feet long. A shaft from No. 3 reaches to No. 4 drift, the lowest workings in the mine. Future work involves the sinking of a new shaft from No. 3 crosscut about 50 feet north of the drift in order to further develop the property below this level. It is the intention, also, to explore the intersection of the main vein with a fourth limestone band, mentioned above, by extending No. 3 drift farther to the east, and eventually to investigate the intersections of two other veins on the property with these limestone beds. One of these veins crosses No. 3 crosscut about 250 feet north of No. 3 drift. The other vein known as the "Dublin vein" has not yet been reached by the extension of No. 3 crosscut south of No. 3 drift. It is stated that values improve with depth on these veins.

GALENA FARM

Galena Farm, property of Northland Mines, Limited, is largely owned by the estate of the late Patrick Clarke of Spokane and until recently was under the management of his son, P. W. Clarke of Spokane. During the last three years the property was operated under lease to R. Ainslie, of Silverton. Lately the Porcupine Goldfields Development and Finance Company has taken a lease and bond on the property with R. H. McLaughlin, Silverton, B.C., in charge of operations. The property was formerly known as the Currie group and includes about 193 acres of mineral land, situated $1\frac{3}{4}$ miles south of Silverton and about a mile east of, and 1,000 feet above, Slocan lake.

The property was discovered and development begun on it in the late "nineties." No record of its early production could be obtained and it lay idle for many years before recommencement of work in 1915. In that year an adit tunnel was driven to connect with the old workings from a point about 850 feet north of the main shaft which is down 220 feet. A mill with capacity of 100 tons per day was erected.

The vein appears to lie in the same strong zone of fissuring as the Van Roi, Hewitt, and Noonday mines and cuts granitic intrusives in which are inliers of older sedimentaries. The vein strikes north 60 degrees west and dips from 50 to 65 degrees northeast. It varies from 9 to 14 feet in thickness and is stated to have been traced for about 1,600 feet. Ore minerals are chiefly galena and blende associated with a gangue of quartz, siderite, and fragments of wall-rock. Some native silver is also present. The ore includes high-grade lenses suitable for hand sorting, but is, in the main, complex in composition and essentially a concentrating proposition.

HEWITT

The Hewitt mine is the property of "Hewitt Mines, Limited," a private company of five owners with headquarters in Spokane. M. S. Davys of Kaslo, B.C., is manager and one of three directors. The property includes fifteen claims and fractions covering about 600 acres. It is situated on a spur of Eightmile ridge and is reached from Silverton by road and trail. An aerial tramway, 5,270 feet long, connects the mine workings with the Hewitt mill. The latter has been erected on the north side of Silverton (Fourmile) creek and is reached from Silverton by a good road over a distance estimated at about $3\frac{1}{2}$ miles.

Discovered in 1892 the property has been worked at intervals since that time by several individuals and companies. Up to the end of 1910 it produced about 18,500 tons of ore which gave net returns of $222,663.65, nearly all in silver. Development work continued from 1917 to 1919 resulted in opening up large shoots of ore between Nos. 7 and 8 levels. This property is developed by eight tunnels, giving a vertical depth of about 1,200 feet below the apex of the vein. No. 9 crosscut, 375 feet, vertically, below No. 8 level, is now in 420 feet and is expected to cut the vein at 1,800 feet from the portal. In recent years leasers have been opening up the older workings on the upper levels and continuing development on No. 9 crosscut, which is being driven from the northern slope of the hill overlooking Silverton creek and 865 feet west of the portal of No. 8 adit. In addition to developing the main vein it is expected that this crosscut will intersect, at about 600 feet from the portal, another vein which outcrops below the portal of No. 8 tunnel.

The country rocks include black, massive to laminated, argillaceous sediments including pyritic, carbonaceous, calcareous, and siliceous types. These strike about north 80 degrees east and dip to the north at an average angle of 70 degrees. They are intruded by dykes and by tongues from the Nelson batholith whose contact with the sediments appears in the mine workings.

The zone of fissuring on this property is one of the strongest in the Slocan and presents excellent indications of permanence with depth. It has a general east-west trend, an average dip of 70 degrees north, and includes a system of four distinct though connected fissures, all of which are ore-bearing, although the bulk of the ore has been produced from the "North" and "Main South" veins, respectively. The vein filling consists largely of country rock, crushed to gouge or brecciated and cemented by quartz. The ore is for the most part of the "dry" type with quartz the predominating gangue mineral. Ore consists of steel and cube galena, and pale and dark brown zinc blende in a gangue of quartz and siderite with, occasionally, a little calcite. Grey copper is commonly present with both blende and galena. Argentite and native silver have also been observed, the latter occurring in mossy aggregates and in leaf and wire forms. Pyrite is present and is said, in some cases, to carry 70 to 80 ounces in silver. Locally, ruby silver occurs in films and clusters of crystals. Stibnite also occurs in lumps and clusters of minute, acicular crystals. On the upper levels the ore was richer in and near the granite than elsewhere. The highest grade zinc ore was found on No. 5 level.

LUCKY JIM

The Lucky Jim mine is owned by the Lead and Zinc Company, Limited, Spokane, Wash. Andy Larsen of Spokane is manager and Matt Ulvila, Zincton post office, is superintendent. The property includes nine claims and two fractions, and is located just above the Nakusp and Slocan railway at Zincton station near the lower end of Bear lake.

The Lucky Jim mine has had a most interesting history. Discovered in 1892 and first worked for the silver-lead content of its ores it later developed into an important producer of zinc. Most of its ore in pre-war times was shipped to the Empire Zinc Company's smelter at Denver, Colo. The disastrous fire of 1910 destroyed most of the surface equipment, including a new tram-line. Financial difficulties of this period were followed by a number of years litigation and the accumulation of a considerable debt. About 1914 the property came under the management of A. Larsen of Spokane, under whose guidance the mine has made excellent progress and during the period of the Great War ranked among the more important zinc producers of the district.

The mine has been opened by six adit tunnels, giving a vertical depth of 930 feet. Most of the work has been done above No. 4 level and except on the Big Fracture zone, which is now being developed, a large part of the ore above this level has been extracted, leaving the future of the property partly dependent on the ore found between Nos. 4 and 6 levels which open up a block of ground with a vertical depth of 620 feet.

The ore-bodies were formed through replacement of a band of limestone and calcareous sediments at the intersection of cross-veins or fissures striking north 50 degrees to 55 degrees east and dipping at high angles to the northwest. The main lime band consists of limestones and other calcareous strata and varies from 50 to 100 feet or more in thickness. It strikes about north 40 degrees west and has a southwesterly dip varying from 40 degrees to 80 degrees. This band has been considerably brecciated and deformed by regional stresses and is interbedded on either side with argillaceous sediments which are commonly thinly bedded but include more massive types. These sediments are cut by a great number of acid porphyritic intrusives, chiefly in the form of sills. In a distance of 600 feet along the railway spur to the east of the ore bunkers eighteen of these sills were encountered. These ranged up to 15 feet in width, but averaged less than 5 feet. The productive part of the veins is in the calcareous rocks only. The ore occurs in chimney-like shoots, following the intersection of veins with the limy bands, or may form broad shoots by replacement along the bedding for 50 feet or more on either side of the major vein fractures. There are three major fractures on the property. These may be referred to, in order from west to east, as the Glory Hole fracture, the Main or Central fracture, and the Big fracture. In addition, three other fractures, included within a distance of 125 feet west of the Main fracture, have each contributed important shoots of ore above the 400 level and were important factors in the formation of the large ore-shoot above the 500 level.

Zinc blende is the predominant ore mineral and the mine is essentially a zinc mine. The blende is associated with galena which was more abundant in the upper levels and is showing up well as development is carried farther into the hill. Pyrite is an abundant mineral and appears to be more intimately mixed with the blende in the lower than in the upper levels. Pyrrhotite and arsenopyrite are present in minor proportions.

Considerable work was done in the early years by open pits, of which the chief was the Glory Hole above No. 4 level where the ore had been partly oxidized and afforded a conspicuous outcrop. Since 1916 most of the work at the Lucky Jim mine has been done on the ore-bodies of the Main Fracture zone between Nos. 4 and 5 levels. The work of this period includes the projection of No. 3 adit to the Big Fracture zone. Recent developments on the Larsen stope above No. 3 level have proved a large shoot of excellent mill feed, carrying a considerable proportion of galena as well as the more abundant and characteristic zinc blende.

LUCKY THOUGHT

The Lucky Thought mine is owned by the Consolidated Mining and Smelting Company of Canada and is under lease to M. S. Davys, Kaslo, B.C., who is subleasing to others.

The property is situated on the south side of Silverton (Fourmile) creek about 4 miles by road from Silverton. It was located in December, 1910, by the late T. J. Lloyd and production begun in 1914 when the first shipment of 36 tons was made to Trail. In all, some 3,879 tons of ore has been shipped from this property to the end of 1924. The ore averaged about 23 ounces in silver and 7 per cent lead and carried some zinc values. The property is developed by four adit tunnels, giving a vertical depth on the vein of about 500 feet. Prior to October, 1916, all stoping was done between Nos. 2 and 3 tunnels. Since that time No. 4 adit tunnel, 300 feet below No. 3, has been driven and an intermediate level established. Most of the ore-shoot has been stoped out above this intermediate (or No. 4) level.

In 1923 a two-bucket aerial tram-line, consisting of a single span 1,140 feet long, was installed between the portal of No. 4 adit tunnel (5th level) and the Hewitt mill where a large part of the ore is concentrated before shipment to Trail. At the time visited three leasers, employing four other men, were working at the mine. Between April, 1924, and July, 1925, these leasers had shipped some twelve cars of zinc and four cars of lead concentrates, the former averaging about 7 per cent lead, 39 per cent zinc, and 39 ounces silver; and the latter 48 per cent lead, 11 per cent zinc, and 75 ounces silver.

The vein is a sheared zone cutting blocky argillaceous sediments on a strike of north 65 degrees east. The dip is about 60 degrees northwest. The hanging-wall is well defined and mostly underlain by a heavy gouge. Sphalerite, galena, and grey copper are the important ore minerals. The blende is the most abundant ore mineral, whereas the grey copper is erratic in distribution and usually associated with the lead ore. Some very rich pockets of galena mixed with grey copper have been obtained from this property.

MARTIN MINE

The Martin group of five claims is owned by J. A. Carter and J. W. Powers of Kaslo, B.C. The claims are not Crown granted.

The property is situated in the upper basin of Dago creek at an elevation of about 2,470 feet above Mansfield creek (South fork, Kaslo creek). It is reached by the Flint mine trail which leads off the Mansfield Creek road about ½ mile below the Cork-Province mine, or 4 miles above Zwicky station on Kaslo creek.

The property was located by J. A. Carter in 1902 and more or less work has been done on it each year since. Development includes work on two adit tunnels 136 feet vertically apart, and on an intermediate level 90 feet above the lowest or No. 1 adit. Nos. 1 and 2 adits have lengths of 600 and 145 feet, respectively, and the intermediate level is 250 feet long. The levels are connected by raises, and, in addition, several hundred feet of crosscutting to, and drifting on, other veins than the main vein has been done on No. 1 and the intermediate levels.

The rock formation in the vicinity of the Martin mine is the Nelson batholith which has the composition here of a granite or acid granodiorite. The ore deposits occur in a fissured or fractured zone which has a general trend of about north 50 degrees east and is marked on the surface by the position of a narrow, steep ravine running up the rocky hill-side. The course of the ravine is also coincident with the occurrence of a narrow, irregular band of dark micaceous rock which is probably a dyke, although so altered as to render its identification uncertain. The principal vein strikes about in line with the gulch and dips to the west at from 65 to 70 degrees. At least two other veins converge from west of the portal of No. 1 adit towards the main vein which they intersect towards the face of this adit. Above No. 1 level these veins seem to come together near the face of No. 3 adit. The vein filling is composed of sphalerite, galena, and subordinate amounts of pyrite and chalcopyrite associated with a quartzose gangue and altered wall-rock. Where best developed the ore is several inches to 2 feet wide and in places is composed of nearly solid galena.

The pitch of the ore-shoots seems to be to the southwest at about 45 degrees. The largest shoot was exposed in the intermediate level where it proved continuous over a distance of about 100 feet.

MOLLY HUGHES

The Molly Hughes property, consisting of five claims, Kinkora, Tryon, Real Idea No. 2, Molly Hughes, and Pinto, is owned by H. Clever of New Denver. The claims are located on the northwest slope of Carpenter (Goat) mountain and extend to Slocan lake at a point about ½ mile north of New Denver.

The ore deposits at the Molly Hughes mine are "dry" and represent a type peculiar to those occurring at a number of properties situated on the western and southwestern flanks of Carpenter mountain. The formation in this section is chiefly a granitic intrusive[1] which occupies a nearly circular area about 1½ miles in diameter lying to the northeast of New Denver. Small inliers of older metamorphosed sediments occur within this area, but the ore-bearing veins are mostly in the intrusive rock. The veins are fissures and where most strongly developed give evidence of more or less crushing and shearing along their course.

On the Molly Hughes property at least three such veins occur and have had more or less development work done on them. Two of these veins, the Kinkora and Real Idea, are roughly parallel striking north 50 degrees west and dipping at an average angle of 50 degrees northeast. The third vein lies to the east of the underground workings on the other two veins and strikes more nearly north and south.

Recent work has been confined to the Kinkora vein which has been developed on three levels, giving a vertical range of about 150 feet. The main working adit is on No. 2 level, which reaches the vein by a crosscut 325 feet long. The portal of this crosscut is close to, and only a few feet above, the rocky shore of Slocan lake. The lowest or No. 3 adit is reached by a shaft at the face of the crosscut to No. 2 drift. All the workings on this vein lie below the level of the railway bed, which at this point is about 150 feet above lake-level, and the drifts themselves are not far from being directly under the railway. The vein has been followed underground for a distance of about 900 feet in the granitic formation. It varies from 3 inches to 8 feet wide and is composed of bands or irregular lenses of quartz associated with more or less altered wall-rock. The vein is interesected by a number of fault-planes striking a few degrees east of north and usually dipping at a high angle either to the east or west. These faults have effected displacements in the vein up to about 80 feet. The pay-streak favours the hanging-wall, or, as is most noticeable in the main or No. 2 drift, there may be two pay-streaks varying from less than an inch to about 8 inches wide and occurring one on the hanging-wall and the other nearer or at the foot-wall. The gangue is quartz, either massive and white or showing ribbon and comb structure and discoloured by included matter. The ore minerals are galena, grey copper, chalcopyrite, and zinc blende. The important values are in silver and gold and are very erratic.

[1]Geol. Surv., Canada, Map 1667.

The ore is stated to run about 2 per cent in zinc and up to 6 per cent lead. Selected specimens are said to have assayed as high as 2,700 ounces in silver and $70 in gold. In 1910, 375 tons gave 66 ounces gold, 26,000 ounces silver, and 3,000 pounds lead.

The long crosscut on No. 2 level of the Kinkora vein would, if projected about 600 feet farther, strike the Real Idea vein, on which some development work has been done. This vein has been proved by open-cuts to extend eastward from the present workings for a distance of about one-fourth mile. It shows up strongly in the open-cuts, but does not appear to be as well mineralized as the Kinkora vein. A third or "Molly Hughes" vein occurs on the claim of that name and appears to strike almost at right angles to the others. The old workings on this vein have fallen into disrepair and little could be seen at the time examined.

MONITOR

The Monitor mine at Three Forks is owned by the Roseberry-Surprise Mining Company and is under lease to George Gormley of Three Forks, B.C. (Alamo). The group includes three claims and two fractions situated to the south of Three Forks opposite the mouth of Kane (North fork, Carpenter) creek.

The mine is developed by five adit tunnels, giving a vertical depth of about 500 feet below the apex of the vein. The vein is a fissure cutting blocky, argillaceous, carbonaceous, and calcareous sediments, and a couple of quartz porphyry sills or dykes, on a general strike of north 45 degrees east. The dip is to the southeast at an angle which is usually steep, varying from 60 degrees to vertical. The vein varies in thickness from a few inches to 4 feet or more and is offset along its course by several faults which persist from the surface to the lowest level and have effected displacements for distances varying mostly between 20 and 40 feet. A major fault near the face of Nos. 2, 3, and 4 tunnels has abruptly terminated the ore-shoots in this direction. The throw of this fault had not been determined.

The vein filling commonly lies between smooth, slickensided walls, but is rather tight in the lower levels. It is composed of more or less crushed country rock with lenses or bands of quartz, siderite, calcite, and ore. The ore consists of galena (banded, steel, and fine cube) zinc blende, and pyrite. Above Nos. 1 and 2 levels the vein material included considerable carbonate ore which has been worked out. No. 3 level developed several ore-shoots containing galena and zinc blende as the important ore minerals. At the level of No. 4 adit the ore carries a high percentage of pyrite and averages $4 in gold to the ton, but is low in silver. No. 5 level has shown ore carrying better lead and zinc values, but has been developed for only a comparatively short distance.

During the past four years the property has been under lease to George Gormley who has shipped ten cars of lead-silver and two cars of zinc-silver ore. The best returns from this were said to have given 103 ounces in silver. Hand-sorted material averaged from 50 to 60 per cent lead. Most of the ore so far developed has been worked out.

QUEEN BESS

The Queen Bess property, including some ten claims and fractions, is owned by Cunningham Mines, Limited, Alamo, B.C. It is situated on the east side of Howson creek and is reached by road from Alamo station or by the Queen Bess trail from Sandon, a distance of about 6 miles.

The two most important veins on the Queen Bess property are called the Main or "A", and the North or "C" veins, respectively. The Main vein has produced most of the ore from the property, and has been developed by ten levels giving a vertical depth of about 630 feet below the outcrop. The vein cuts argillaceous and quartzitic sediments on a strike varying from north 45 degrees east to south 85 degrees east, and dips southeast at from 35 to 55 degrees, with local flattenings as low as 20 degrees. The sediments have a general strike of about north 55 degrees west and dip to the southwest at from 40 to 60 degrees. They are intersected by a number of porphyry dykes and sills having, in general, about the same strike as the enclosing rocks. This strike also corresponds closely with the lines of major faulting and shearing on the property. The larger ore-bodies have been found within an inner and an outer zone in the underground workings, leaving an intermediate zone, several hundred feet in length, of comparatively barren ground. This intermediate zone is coincident with a general roll in the vein from a northeasterly to a more easterly direction. The inner zone has produced a large body of ore above the No. 7 level and is terminated to the northeast by a strong fault or shear-zone. Other faults of similar character have terminated the ore-bodies on other sides and the interpretation of their significance affords one of the chief problems connected with ore deposition on this property.

The North or "C" vein has been opened by two drift tunnels 130 feet apart vertically. It strikes north 50 to 55 degrees east and dips southeast at from about 70 degrees to vertical. Some stoping has been done on this vein and some ore shipped. At the time visited further development was being undertaken.

The trend of the A and C veins at the Queen Bess mine is about that of the major jointing in the enclosing rocks. The main vein varies in thickness from 1 to 25 feet or more, the filling in the wider parts being largely crushed rock. In the richer parts of the ore-shoots, however, this filling included several feet of clean ore which favoured the hanging-wall side. As a rule the straighter and steeper parts of the vein, where enclosed by strong walls, have contained the best ore. The important ore minerals are galena and sphalerite, the lead ore carrying high values in silver. Quartz is the chief gangue mineral.

RAMBLER-CARIBOO

The Rambler-Cariboo mine, owned by the Rambler-Cariboo Mining Company of Spokane, is situated on McGuigan creek and is reached by road from Seaton Creek valley above Rambler station. The mine is connected with the mill at Rambler station by a Crawford aerial tramway 7,000 feet long.

This property has been one of the steadiest producers in Slocan district. Since 1893 it has produced ore valued at about $2,240,000, and has distributed some $560,000 in dividends. In recent years it was worked under a lease by the late W. A. Cameron of New Denver.

The mine has been developed by fourteen levels, of which Nos. 1, 2, 7, and 4 are tunnels, giving a vertical depth on the vein of about 1,300 feet. The main avenue, No. 14, reaches the vein by a crosscut 4,425 feet long. Shafts connect No. 14 with No. 8 level and No. 8 with No. 3 level. Drifts have been driven in both directions from these shafts and a very large area explored. Development since 1916 has included projection of almost all the levels southward, as the rake of the ore, at least in the lower levels, is in this direction. The drifts have also been extended north to near the limits of the property. In 1919 the company acquired the Jennie and Last Chance No. 4 claims to the southwest of the Rambler claim and the levels have been extended to explore this new territory. The most recent work has included the stoping out of an ore-shoot from 40 to 60 feet below No. 12 level to the south of No. 14 crosscut.

The country rocks include quartzitic, argillaceous, and calcareous beds, both laminated and massive and commonly heavily impregnated with pyrite. These sediments strike from north 10 degrees to north 65 degrees west, and dip mostly to the west and southwest from 50 to 80 degrees. They are intruded by a granitic boss which occupies the central part of the workings underground. In addition to this intrusive there are a number of dyke-like bodies of quartz porphyry varying from a foot to over 100 feet in thickness and mostly striking with, or nearly in line with, the enclosing sediments.

The vein has a general strike of about north 40 degrees east with an average dip about 80 degrees southeast. In thickness it varies from a crack to over 20 feet. It is composed of crushed rock, quartz, a little siderite and calcite, and ore. The ore consists of cube and steel galena, zinc blende, grey copper, and pyrite, with, in places, ruby and native silver and a little chalcopyrite.

The company has not yet installed a flotation process in their mill, but hope to do so if development work shows up a sufficient tonnage to warrant the expenditure.

RICHMOND-EUREKA

The Richmond-Eureka mine is owned by the Consolidated Mining and Smelting Company, and is situated about 1,500 feet above Sandon on the steep eastern slope of the East fork of Sandon creek. The property includes seven claims and fractions aggregating, in all, about 146 acres of mineral lands.

The Richmond-Eureka vein was staked by Bruce White in 1891, but active mining operations were only commenced in 1908, previous to which time little ore had been shipped. The years 1908 to 1914 included the period of greatest production. Since 1914 several parties have been leasing the property, but the production has been comparatively small. At present a partnership of four, Stewart, McNab, Thompson, and Watkins, are working on a lease obtained May 1, 1924, since which time they have been doing development work mainly on No. 4 level, but some also on No. 5. They have also been engaged in placering the old dump from No. 5 level. From this dump they took out 20 tons of zinc ore during the summer of 1924 and up to July, 1925, had taken out some 22 tons more. This ore is rawhided down to Sandon, as the aerial tram installed years before from the portal of No. 5 to the railway at Sandon is not now in working order.

The country rocks are quartzitic, argillaceous, and calcareous sediments intersected by a few basic, micaceous dykes and dykes of quartz-biotite porphyry. The vein is developed by open-cuts and tunnels, including the lowest or Slocan King tunnel on the adjoining property of Silversmith Mines. The workings give a vertical depth of 1,230 feet below the outcrop, and include eight drift tunnels, of which Nos. 3 to 6 are connected by raises. The vein is the eastern extension of the Slocan Star vein and has a general strike of north 80 degrees east, with an average dip of 45 degrees south. It occasionally turns and follows formational planes, especially near the basic dykes. In thickness it varies from a few inches to 42 feet, the thicker parts being filled largely with crushed rocks and horses of the same. The vein seems best developed in the softer slaty rocks. Two important shoots have been developed. Of these the ''Main'' shoot was much the larger, varying, as stoped, from a few inches to 10 feet in thickness and with a maximum width on the dip of about 267 feet. Streaks or bands of steel galena from 1 to 2 inches wide were found close to the foot-wall, but the main pay-streak of clean galena occurred on the hanging-wall side and ranged up to 8 feet thick. This shoot pitched to the east at about 40 degrees. Beyond this main shoot the vein seemed to split up and follow several fractures. The company followed the most southerly of these veins and in so doing struck a second but much smaller shoot occurring in harder ground which appears to be less favourable for ore deposits on this property. On the chance that it might have been better to have followed the foot-wall past the main ore-shoot the present leasers have been driving a crosscut north from No. 4 level and have reached some promising ground which, though not yet showing much ore, has in its geological relations a distinct resemblance to those at the main ore-shoot. This work underground has been supplemented by some surface prospecting.

The metallic minerals are steel and cube galena, zinc blende, pyrite, and a little chalcopyrite. Grey copper is usually present, and leaf silver, though rare, has been noted. The gangue minerals include siderite, quartz, and a little calcite.

RUTH-HOPE

The Ruth-Hope group of fourteen Crown-granted mineral claims, covering about 400 acres, is owned by Ruth-Hope Mining Company, Limited, Sandon, B.C., a company incorporated in April, 1923, with registered office in the Vancouver Block, Vancouver, B.C. The property lies to the south and southwest of Sandon between elevations of 3,500 feet and 5,800 feet. The group adjoins the property of the Silversmith Mines, Limited, to the west.

The Ruth-Hope veins were discovered in the early "nineties", since which time they have yielded a production that ranks high among the properties of the district. The Ruth vein was worked for silver-lead until 1904 and for zinc blende until 1909. Development on the Hope vein commenced in 1906 and shipments were made nearly every year up to 1919, since which time production has been largely from the Ruth, Ruth No. 2, and, quite recently, the Silversmith vein, whose continuity into Ruth-Hope ground has been proved. Other veins of some prospective value occur on the property, but these have not yet been developed to the point of production.

The rocks in the vicinity of this property include slaty, argillaceous, siliceous, and calcareous sediments having a general strike of about north 35 degrees west and dipping mostly to the southwest at angles varying from 20 degrees or less to vertical. These rocks are intruded by a number of quartz porphyry dykes which are most conspicuously exposed within a zone or belt several hundred feet wide striking about in line with the general trend of the sediments across the workings on the Ruth vein and about in line with the big porphyry intrusive on the adjoining Silversmith property.

The workings on the Ruth and Ruth No. 2 veins lie to the east of, and consequently lower down the hill-side than, those on the Hope vein. They include development work on nine levels connected by raises and shafts giving a vertical depth of about 800 feet.

Recent important developments at the Ruth-Hope mines include a long crosscut driven from No. 5 level of the Ruth mine to tap the Silversmith vein on its westerly extension from the adjoining property of Silversmith Mines. Several feet of milling ore was encountered at the intersection of the crosscut and the company are now engaged in exploring the extension of this vein to the southwest on the Blue Grouse claim. Other developments on this property within the last few years include the opening up from the surface of the Ruth No. 2 vein by the Stewart tunnel and by an inclined shaft connecting with two lower levels reaching to 89 feet below this tunnel. A second shaft from the lower of two levels connects with a fourth and lowest level on these workings and gives a vertical depth on the vein of about 140 feet. From the east end of the lowest level a third shaft 217 feet long on a 45 degree dip reaches to No. 2 level of the Ruth mine. In all, some 1,500 feet of drifting, crosscutting, and shaft work have been done on these upper workings on the Ruth No. 2 vein and ore to the value of about $75,000 has already been extracted. In these upper levels the vein is irregular in strike, but is, in general, about parallel with the Hope vein and also dips at a considerably lower angle to the south than the Ruth vein. It varies greatly in width, spreading out in the lowest level of these upper workings to about 28 feet, including pay ore on both foot and hanging-walls with several feet of waste between. The ore is considerably oxidized in these levels. Galena is the more abundant sulphide, but zinc blende, where found, usually carries high values in silver. The vein filling includes an abundance of crushed country rock. What is regarded as the probable continuation of this vein has been picked up towards the west end of No. 4 adit on the Ruth workings and has been followed for a distance of about 400 feet. Recent work near the face of No. 4 has exposed some good concentrating ore carrying mainly sphalerite, but also quite a little galena. Stoping toward the west end of this level has, it is stated, exposed concentrating ore across a width of up to 12 feet. These workings were formerly abandoned because of their zinc-like character. No ore has yet been encountered in No. 5 level, which lies 250 feet vertically below No. 4 level, but in the main raise to No. 4, and about 100 feet above No. 5, a vein about 2 feet wide, carrying blende and siderite, is exposed and was said to be close to an underhand stope from No. 4 level. This ore-body is thought to be in the foot-wall section of the Ruth vein, in which case it has not yet been prospected at the level of No. 5 tunnel.

The Ruth vein has been worked out over a maximum length of about 700 feet and a vertical distance of 220 feet above No. 3 level. Recently, two short drifts, 35 and 90 feet, respectively, below No. 3 level, and connected by a winze from this level, have proved the continuation of concentrating ore to at least this depth. The vein has a general strike of about north 45 degrees east and dips to the southeast at an average angle of 50 degrees. In general it may be said the Ruth vein is steeper and better defined than either the Hope or Ruth No. 2 veins.

The Hope vein has been an important producer since commencement of development work in 1906. It is developed by five adit tunnels, giving a vertical depth of nearly 600 feet below the surface. No. 4 is the main avenue and is connected with No. 2 by an incline shaft. When visited, leasers were at work above No. 1 level. The vein has a general east and west strike and dips to the south at angles varying from 25 to 40 degrees. It varies in thickness from less than a foot to about 40 feet, the walls being in many places ill-defined. The filling consists largely of crushed country rock with calcite, siderite, quartz, and ore. The main productive zone extended from a little below No. 4 level to the surface and had a length on No. 2 of about 550 feet. It apparently pitches to the east or out of the hill. The large bands of lenses of calcite up to 3½ feet thick, which lie next or near the hanging-wall and against which the ore seems to have formed, are a feature of this zone. The ore is chiefly clean galena and blende; grey copper, chalcopyrite, and pyrite also occur. Limonite and anglesite occur in the oxidized parts of the ore-bodies. Some of the zinc blende carried high values in silver, an assay of a picked specimen made by H. A. Leverin of the Mines Branch giving 318·38 ounces silver and 0·02 per cent copper. The most likely area for future development and production on this vein is towards the east, in line with the apparent pitch of the ore-bodies. What is regarded as a possible continuation of this vein has been exposed about 800 feet from the Silversmith vein, in the long crosscut from No. 5 level of the Ruth mine.

SLOCAN SOVEREIGN

The Slocan Sovereign mine, owned by Cunningham Mines, Limited, Alamo, B.C., is located about 1,500 feet above Sandon on the northern slope of Carpenter Creek valley. It is reached from Sandon by road and trail over a distance of about 3 miles. The workings are located on the Slocan Sovereign claim which adjoins the Omega to the north and the Twilight to the east, both of which adjoining claims belong to the Reco group.

The mine is developed by three adit tunnels connected by raises and shafts to a number of blind drifts. The aggregate amount of underground workings is over 4,000 feet. The workings mostly follow the vein which has a strike of about north 40 degrees east and dips about 60 degrees to the southeast.

The vein on this property is one of a number of important veins or vein systems on this slope of Reco mountain. All of these veins run in a parallel, or nearly parallel, direction, controlled by a master system of jointing which has developed convenient channels for ore deposition. Their valuable mineral content has been proved on such properties as the American Boy, Last Chance, Surprise, Noble Five, Reco, Goodenough, and Grey Copper.

The country rocks are represented by a variety of argillaceous, siliceous, and calcareous sediments, including both slaty and massive types and mostly fine grained. These rocks have a northwesterly strike and dip to southwest at angles varying from 45 degrees to vertical. They are intersected by a great number of dykes varying from a few inches to several hundred feet in width. These dykes are mainly light-coloured feldspar and feldspar-quartz porphyry types, but include a number of dark green basic types which are usually not over a few feet in width and probably represent a somewhat earlier period of intrusion than the others. Both types are present on the Slocan Sovereign claim and appear in the underground workings, apparently nearly parallel with the vein or cutting across it at a small angle to the north or east of north. In some places they form both walls, but more commonly occur only on one and that chiefly the hanging-wall. The vein is traversed by a number of faults usually showing small displacements to the left.

The vein has been traced from Nos. 1A and 1B levels above No. 1 adit tunnel to the lowest or No. 3 adit tunnel, a vertical distance of about 450 feet.

SLOCAN STAR-SILVERSMITH

The Slocan Star-Silversmith group of mines is owned by Silversmith Mines, Limited, Sandon, B.C. The property includes fourteen Crown-granted claims, embracing 298 acres. It lies mostly between the East and West forks of Sandon creek about ½ mile to the south of and between 500 and 1,500 feet above the town of Sandon. The adjoining property of the Ruth-Hope mines to the northwest and the Richmond-Eureka property to the east are located on extensions of the main vein system from the Silversmith property. The new Silversmith mill is located on the railway below Sandon and is connected with the portal of No. 10 adit, the main avenue for the Silversmith mine, by an aerial tramway 4,600 feet long.

Shipment from this property began in 1894 on completion of the Canadian Pacific branch line to Three Forks. Since that time ore to the value of about $5,500,000 has been produced. This, with the exception of the Standard, represents the greatest return for any property in the Slocan, and at present this mine is, with the exception of the Sullivan mine at Kimberley, the largest producer of silver-lead-zinc ore in the province. In recent years the production has been chiefly from the new Silversmith shoot, whose total production since the autumn of 1918 to May, 1925, has been over 150,000 tons mill feed and some 2,000 tons of clean ore, having a total value roughly estimated at about $2,500,000. The mill feed up to

September, 1922, was stated to average 20·5 ounces silver, 9·3 per cent lead, and 9·1 per cent zinc. The clean ore for this period carried an average of 115 ounces silver and 60 per cent lead to the ton.

The country rocks are largely slaty to massive, argillaceous and siliceous sediments, intersected by a number of porphyry dykes including some distinctly basic types. One stock-like mass of feldspar-quartz porphyry, from 400 to 500 feet wide, is closely associated with the ore deposits and intervenes between the Slocan Star and Silversmith ore-bodies.

The vein has been developed by six adit tunnels, Nos. 1, 2, 3, 4, 5, and 10, connected by shafts and raises from which five blind levels, Nos. 6, 7, 8, 9, and 11 have been run. In all there are nearly 6 miles of underground workings on this property, including 16,000 feet of drift, 8,300 feet of crosscuts, and 5,600 feet of raises. No. 10 is the main haulage level and reaches the vein by a crosscut 2,100 feet long and at a depth of about 1,200 feet on the dip of the vein. No. 11 drift on the new Silversmith shoot is about 100 feet below No. 10 level. In drifting to the west or towards the Slocan Star ore-body, on No. 10 level, two ore-shoots were encountered, the first evidently representing the continuation of the main ore-shoot in the old Slocan Star workings. To the west of the main crosscut, No. 10 drift discovered the new Silversmith shoot from which most of the more recent production has been mined.

The Slocan Star-Silversmith vein has a general northeasterly trend and dips southeast at an average angle of about 45 or 50 degrees. In the lower levels the vein steepens to from 70 to 75 degrees. In detail the course of the vein is markedly irregular, as the intermediate section between the Slocan Star and new Silversmith ore-bodies apparently makes a remarkable bend to the north around the large porphyritic intrusive body previously mentioned. This section of the vein is mostly barren, the principal ore-shoots occurring to the east and west of this porphyry and chiefly on the Slocan Star and Rabbit Paw claims, respectively. On the Slocan Star claim the two principal ore-shoots occur where the vein makes a broad swing from a southerly to a northeasterly course towards Richmond-Eureka ground. On the Rabbit Paw claim the new Silversmith shoot has the large porphyritic intrusive for a hanging-wall, represents the steepest position of the vein, and also occurs where the vein makes a turn from a northeasterly to a more westerly direction. A fourth shoot, known as the Old Silversmith, occurs on the Silversmith claim to the west of No. 10 crosscut. This shoot has been worked above No. 5 level and apparently does not continue to the lower levels.

The vein varies in width from a few inches to about 80 feet and contains crushed fragments as well as large and small horses of country rock, and quartz gangue and ore. Many of the bands and lenses of siderite and quartz strike diagonally across the vein, cutting off at the walls, and cross fractures are more numerous in the productive parts of the vein. The ore consists of galena, zinc blende, grey copper, chalcopyrite, and pyrite in a gangue of siderite and quartz. Bands and lenses of clean ore are commonly found and may follow either wall, but, in general, the ore and vein filling are intimately mixed with the better ore predominating on the hanging-wall side.

STANDARD, EMILY EDITH, AND ALPHA MINES

These mines are owned by the Standard Silver-Lead Mining Company of Spokane, and are being operated under the management of W. H. North, Silverton, B.C. They occupy the lower southwestern slopes of Idaho peak above the valley of Silverton creek and are reached by wagon road from Silverton. These mines are all regarded as including parts of the main or Standard vein. The upper or Alpha workings include five tunnels driven on the vein, giving a vertical depth of about 550 feet. The uppermost workings, from which most of the ore was obtained, are at an elevation of about 2,800 feet above Slocan lake. This mine has been idle since 1894. The Standard mine lies in an intermediate position between the Alpha and Emily-Edith properties and has been by all odds the greatest producer of the three. It is developed by six tunnels driven on the vein and connected by raises, giving a vertical depth of about 560 feet. The lowest or No. 6 is the main working tunnel and is connected to the mill on Slocan lake by a Riblet aerial tramway 7,900 feet long. The uppermost of these workings is about 300 feet below the lowermost workings on the Alpha property. On Emily Edith ground there are some eight tunnels, 1A, 02, 01, 1, 2, 3, 4, 5, of which six have encountered and drifted on the vein and give a vertical depth on it of about 400 feet. Nos. 2 and 5 tunnels are also referred to as Nos. 7 and 8 of the Standard. The lowest or No. 5 is about 720 feet above Slocan lake.

The rocks in the vicinity of the mine workings include dark grey to black, argillaceous, siliceous, calcareous, and carbonaceous sediments with both massive and laminated slaty types. These are intersected by a few dykes and sills, one of which, a quartz diorite porphyry, forms the foot-wall of the Standard vein for some distance in the upper levels. A stock or boss of coarser-grained granodiorite occurs along the east side of the Standard claim and is doubtless connected at depth with the large area of batholithic rocks to the south of Silverton (Fourmile)creek.

On Alpha ground the principal ore-shoot outcropped on the surface, pitched into the hill, and has not yet been encountered in the lower levels No. 4 and No. 5. The production to 1894 from this shoot amounted to about 1,200 tons of clean galena and oxidized ore averaging 105 ounces silver and 60 per cent lead to the ton.

The main ore-shoot on the Standard property extended from No. 3 level to below No. 6, reaching its maximum development on No. 5, where it had a length of about 400 feet, a width of from 15 to 20 feet of clean lead ore, and an equal width of milling ore containing smaller lenses or masses of clean galena. This body of ore represented what was probably the largest shoot of high-grade galena ore ever uncovered in British Columbia, and has been chiefly responsible for the large production of the Standard mine, the greatest in the history of Slocan district. It has been mostly stoped out above No. 6 level. No. 7 level driven from Emily Edith ground and in over a mile has not yet encountered this shoot, but may not be far enough in, or, in such a wide vein, may have missed the main shoot. Most of the development work on the Standard group in the last ten years has been on other ore-shoots discovered between Nos. 5 and 6 levels beyond the main ore-shoot. Here two intermediate levels revealed considerable bodies of concentrating ore, much of which has been stoped out. This ore carried mostly zinc values with depth.

The ore-bodies on the Emily Edith lie about 3,000 feet west of the main ore-body on the Standard and mostly occur towards the western or adit end of the workings. Only No. 2 level (No. 7 of Standard) has been projected to anywhere near the main ore-shoot of the Standard mine.

The so-called "Standard vein" is a strong fissure along which much subsequent movement, and more or less intense shearing, have taken place. In strike it varies from northeast to nearly east and west, with dips to the south and southeast varying from 30 degrees to vertical and averaging about 45 degrees. At the Alpha mine the vein strikes northeast and dips from 30 to 40 degrees southeast, and varies in width up to 4 feet. At the Standard mine the strike averages about the same as on the Alpha, but varies in part to nearly east and west. The dip averages about 40 degrees southeast, but is somewhat steeper in the vicinity of No. 5 level. In the Standard workings the vein has a maximum width of about 150 feet and in these wider parts usually shows two well-marked fissures, one on the foot- and one on the hanging-wall, with varying widths of massive and crushed rock between. On the Emily Edith workings the vein strikes nearly east and west and dips to the south at from 50 to 60 degrees. It varies in thickness up to 20 feet or more, with, in places, distinct hanging- and foot-wall fissures.

The vein filling on these properties includes much broken, crushed, and slickensided country rock. The chief gangue minerals are siderite, calcite, and quartz, the first two being most abundant in the main Standard ore-shoot. The ore minerals include galena, sphalerite, grey copper, and chalcopyrite, with, in places, some ruby silver. In the main standard ore-shoot the ore-body was composite in character, being made up of distinct tubular-shaped lenses and rounded masses of clean galena, and other lenses of mixed ore and gangue minerals. Between Nos. 6 and 7 levels and not far northeast of this shoot are large stopes from which much zinc ore was mined. On the Emily Edith the chief ore mineral is zinc blende, but more or less galena is associated with it. Chalcopyrite is also present and in some places ruby silver has been found. Ore has been produced on all the main levels of the Emily Edith and varies from 1 to 4 or more feet in width. Present work is being done by leasers on the hanging-wall section of the vein between the lower two levels, which are about 90 feet apart.

SURPRISE

The Surprise group consists of Surprise, Surprise No. 2, and Summit Fraction claims, and is owned by the Roseberry-Surprise Mining Company. J. P. MacFadden, New Denver, B.C., is manager for the company.

The property is situated in the Antoine basin at the head of the south fork of McGuigan creek and at an elevation of about 7,400 feet above sea-level. The mine is reached from Sandon by a trail which communicates with No. 3 tunnel of the Last Chance mine on the opposite or Carpenter Creek slope of the hill. This tunnel, at an elevation of about 3,300 feet above Sandon, is the main avenue to the Surprise mine. The aerial tram of the Last Chance is used for transportation purposes from the mine to Carpenter Creek Valley road, one mile above Sandon.

The main vein on the Surprise is developed by ten levels, including No. 3 Last Chance tunnel, the lowest level in the mine. These workings give a vertical depth of about 900 feet on the vein. The upper three levels are tunnels driven from the northern side of the summit in the Antoine basin. All except these three and No. 3 Last Chance level are blind. The lowest tunnel on the northern slope is the main working adit on that side of the divide and reaches the vein by a crosscut 320 feet long. Raises connect all the underground workings between the lowest and the second highest tunnels. The main raise from No. 3 Last Chance level is driven from a point about 2,650 feet from the portal and carries up to No. 3 level of the Surprise, a vertical distance of about 300 feet.

The vein cuts laminated and massive, argillaceous, siliceous, and calcareous sediments, and dyke rocks, on a general northeasterly strike, and dips to the southeast at an angle averaging 55 or 60 degrees. An interesting feature of the mine is the presence of a quartz-porphyry dyke several hundred feet in width, across which the main vein strikes and within whose limits the main ore-shoot occurs. The vein is a fissure or fissured zone and, apparently, the northeasterly extension of the American Boy and Last Chance vein. It varies in width from a few inches to over 15 feet and has a filling of crushed country rock, siderite, and quartz gangue, and ore. The wider parts of the vein were, as in places in the main ore-shoot, filled with clean ore, but more commonly the ore is confined to relatively narrow pay-streaks along either foot- or hanging-wall. In general the vein is more regular in the porphyry dyke. In the upper levels the ore-bodies occur in slaty sediments and are very irregular in occurrence, though high in silver and lead values.

The chief ore minerals are argentiferous galena and sphalerite, the former predominating in the upper workings where it carries gold-silver values. The main ore-shoot also carried a large proportion of lead ore, particularly in its more central parts. This shoot extended up to between No. 4 and No. 5 levels and has been mostly stoped out above the sill floor.

VAN ROI

The Van Roi mine is owned by Cunningham Mines, Limited, Alamo, B.C. The property includes some ten or eleven claims situated south of Silverton (Fourmile) creek and west of Granite creek. It adjoins the Hewitt mining property to the west and is reached by road from Silverton, a distance of about 4 miles.

The mine was discovered in 1892 and acquired from the Moynahan Brothers in 1897 by M. S. Davys. In 1906 it was transferred to the Van Roi Mining Company, a subsidiary of the Le Roi No. 2 of Rossland, who operated it until about 1916 when it was acquired by the present owner.

The mine has been opened on the west side by four tunnels (Nos. 1, 2, 3, and 4) and on the east side by four others (Nos. 5, 7, 8, and 9). No. 9 gives a vertical depth of 1,350 feet below the outcrop of the vein. Nos. 5 and 9 tunnels are connected to the Van Roi mill opposite the mouth of Granite creek by aerial tramways with drops of about 980 and 600 feet respectively, the distance from No. 5 being about 2,100 feet.

The country rocks include well-banded and dense, light grey, quartzitic beds, carbonaceous and siliceous argillites, and dark grey shales. There are a few dykes, but the mine is fairly free of such intrusives, although in close proximity to the great batholith of granitic rocks to the south. The strike of the sediments varies from about north 45 degrees east to nearly east and west and the dips are to the southeast and south at angles varying from 55 degrees to vertical.

There are two principal veins, the "Main" or "North" vein and the "South" or "Beryl". The former has a general strike of about north 75 degrees east and an average dip of 70 degrees to the north. The south vein strikes from north 50 degrees east to north 60 degrees east and dips northwest at from 65 to 75 degrees. The main vein has a developed length of about 3,000 feet on the longest or No. 7 tunnel. The south vein has been explored for a maximum length of about 500 feet on No. 4 level, the development on this vein being confined to the western side of the hill between Nos. 3 and 7 levels. A recent important discovery of rich silver-lead ore on No. 9 level, from what is thought to be a continuation of the south vein, has added to the future possibilities of the mine. The strike of the two veins will cause them to come together to the east of the present workings on the south vein. Diamond drilling has been used extensively for exploratory purposes on this property.

The veins so far developed have proved remarkably continuous and average several feet in width. The angle they make with the enclosing rocks is small and produces slabby ground and, to some extent, a lack of clear definition to the walls. Ore-shoots have been encountered at irregular intervals and, in general, where cross-fissuring is best developed.

The vein filling includes much gouge and broken rock, together with gangue and ore minerals. The ore consists mainly of galena and zinc blende in a quartz gangue. Grey copper and ruby silver are fairly plentiful in places, both in the lower and upper levels. Native silver, chalcopyrite, and pyrite also occur, the silver, however, being in very small amounts. Siderite and calcite are present in small quantities. The ore is essentially a "dry" ore and is a milling one in the main, although cross-fractures in many places show small lenses of high-grade galena ore. The average grade of milling ore is stated to run from 11·2 to 18 ounces in silver, 4 to 7·75 per cent lead, and 9·1 to 12 ounces zinc per ton.[1] Development and production in recent years have been mostly from the lower levels. Exploratory work is also being conducted at other promising points higher up on the eastern slopes of the ridge west of Granite creek.

WHITEWATER MINE

The Whitewater and Whitewater Deep groups of mines, including some twenty-four Crown-granted claims and fractions, are owned by the Whitewater Mines, Limited, Kaslo, B.C. W. H. Burgess, Kaslo, B.C., is managing director.

The property is located to the west of the lower valley of Whitewater creek and north of Kaslo creek. The portal of the lowest or No. 14 crosscut tunnel is near Retallack station and about 100 feet above the Kaslo and Nakusp branch of the Canadian Pacific railway.

[1]Ann. Rept., Minister of Mines, B.C., 1924, p. 199.

The Whitewater mine was discovered in 1892. It was worked first for silver-lead and from 1904 for both silver-lead and zinc ores. The property has been one of the steadiest producers in the district and is credited to the end of 1924 with a total production of 86,184 tons having a net value, after paying railway and smelting charges, of $1,850,000. Production in the last ten years has been from the work of leasers in the old Whitewater workings.

The mines have been developed by ten tunnels driven from the west slope of Whitewater Creek valley and by one long crosscut tunnel, at No. 14 level, from the valley of Kaslo creek. Between No. 10 tunnel and No. 14 crosscut are three intermediate levels, Nos. 11, 12, and 13, and there are other intermediate levels between the Nos. 7 and 10 tunnels. No. 14 crosscut gives a vertical depth of about 1,865 feet, or over 2,500 feet on the dip of the vein. Most of the ground above No. 7 tunnel has been worked out and present exploration is being concentrated chiefly on the block of ground between Nos. 10 and 14 levels on the Whitewater Deep group. The long crosscut on No. 14 level has been driven in a direction a little east of north for about 2,250 feet and is the main working adit for the mine. At 1,820 feet from the portal this crosscut encounters a vein regarded as the possible extension of the south fork of the Whitewater vein. At 2,000 feet from the portal a main raise has been extended to connect with No. 10 level, a vertical distance of about 375 feet or 520 feet on the slope of the raise. The mine is equipped with an 18 by 24-inch, 8-drill Ingersoll-Cooper compressor driven by a 48-inch Pelton water-wheel under a 500-foot head from Whitewater creek.

Since 1913 little has been done on the Whitewater Deep group which may be regarded as yet in its initial stages of development and production. The company is at present engaged in getting these old workings in shape for further development; in improving the main raise between Nos. 10 and 14 levels; and in investigating the importance of cross-fissuring and the possibilities of the south fork of the Whitewater vein. A permanent camp, including cook-house, bunk-house, and office buildings, has been constructed near the railway at Retallack station. The company hope eventually to erect a mill on Kaslo creek below the present workings.

The formations encountered include slates, blocky argillites, limestones, and other calcareous, carbonaceous, and siliceous sediments. The strike is about east and west and the dip, except where influenced by faulting and local folding, is dominantly to the south.

The great width of limestone and other calcareous sediments is a noteworthy feature of the Whitewater Deep workings. These rocks are more susceptible to replacement processes than the slaty and argillaceous types in the Whitewater group and doubtless afford some explanation for the greater width of some of the ore-bodies in these lower workings. One basic dyke, at least several feet wide, was encountered in No. 10 level and is similar to, if not identical with, a dyke which occurs on the Metlakahtla claim on the east slope of Whitewater valley and which has a strike of about north 10 degrees west and a steep dip to the east.

The Whitewater vein on its strike is closely in line with the enclosing formation, but dips south at an average angle of about 45 degrees, with steeper parts below No. 10 level. It is a strong fissure which, with minor or local exceptions, cuts across the dip of the bedded rock and is the site of considerable movement accompanied by shearing and cross-fissuring. In thickness it varies from a few inches to 50 or 60 feet—averaging probably about 5 feet above No. 7 level. The filling consists of crushed country rock containing irregular lenses of siderite quartz and ore. The pay-streak varies in thickness from little or nothing up to several feet and forms almost one continuous composite shoot from No. 8 level to the surface, with a rake to the east at from 30 or 35 degrees.

The principal ore minerals are galena, zinc blende, grey copper, pyrite, and chalcopyrite. Both siderite and quartz are common gangue minerals. In Nos. 12 and 13 levels several feet of clean zinc blende have been discovered at a couple of places to the west of the main raise. Some galena is associated with it in streaks which commonly favour the hanging-wall side.

Below No. 6 level and at some point east of the lower workings on the Whitewater Deep the Whitewater vein is supposed to split into two main forks striking west and northwesterly at a small angle to each other. West of this split investigations on the Whitewater Deep have been confined chiefly to the foot-wall or north split and to cross-fissures which appear to strike off from this split, at an angle of about 30 degrees to the south of it, towards the assumed position of the hanging-wall or south split. These cross-fissures constitute an important economic feature in these workings. They dip at high angles to the north and where investigated, as on Nos. 12 and 13 levels, are well mineralized, carrying silver-lead as well as zinc values.

WONDERFUL

The Wonderful group, consisting of the Wonderful, Wonderful Fraction, Lookout, Columbus, New Springfield, and Samson claims, is owned by Cunningham Mines, Limited, Alamo, B.C. The mine is situated a mile west and 800 feet above Sandon and is connected with the railway up Carpenter Creek valley by an aerial tramway. The ore is concentrated at Alamo mill before shipment to Trail smelter.

Early shipments were won by ground-sluicing which exposed a narrow pay zone of angular boulders of galena, probably representing a broken-up surface shoot of ore almost in place. One boulder weighed 1,300 pounds. Prior to 1896 the shipments are stated to have amounted to 575 tons, carrying 113 ounces silver and 70 per cent lead.

The main vein is developed by seven levels, numbered from the lowest up: A, B, C, and D, with intermediate levels between A and B, B and C, and C and D, giving, in all, a vertical depth below the surface of about 450 feet. Level A is the longest, having a length along its main branch estimated at about 2,300 feet. It is the only adit tunnel and, consequently, the main haulage level for the mine. The levels are all connected by raises, of which one extends continuously from A level to the surface.

The vein is a sheared fissure having a general east-west trend varying to about 25 degrees north of east toward the eastern part of the productive zone. The dip is to the south and the vein cuts massive to slaty argillaceous sediments and a number of porphyry dykes. The sediments have a general north 15 to 20 degrees west strike and dip to the northeast at angles which are mostly low and in some places almost flat. They are conspicuously jointed in a direction which is closely in line with the main vein. In part, and particularly near the ore-bodies, these sediments are in many places heavily mineralized with pyrite.

The rock structure at this mine is complicated by a series of important shear-zones striking, in general, about parallel with the sediments, but, in part at least, cutting across them at a steeper angle to the east. These faults have effected apparent displacements in the vein over distances of from a few feet to 160 feet or more.

Development and production in recent years have been chiefly from the western section of the mine and mostly to the west of the "Long fault" encountered near the face of B level. This fault apparently displaced the vein about 160 feet to the northwest. Recent development includes the projection of A level about 1,200 feet to a point about 120 feet west of what is regarded as the probable location of the Long fault on this level. A considerable body of milling ore was found near the face of this level and some stoping has been done on this. A raise has also been constructed to connect with B level and thereby develop this ore-body between and above these levels.

The vein filling varies up to 8 or more feet in width and includes more or less crushed wall-rock associated, in the productive parts, with quartz gangue and ore minerals. The latter, including principally galena and sphalerite, are rather irregularly distributed in bands, bunches, or small lenses and are commonly associated with more or less pyrite. Both galena and zinc blende contain good values in silver. From May 1 to December 24, 1923, 10,663 tons were mined, yielding 702 tons of lead concentrates carrying 61,550 ounces silver and 846,775 pounds lead, and 923 tons of zinc concentrates carrying 59,074 ounces silver, 205,077 pounds lead, and 625,313 pounds zinc.

MINING, MILLING, GEOLOGICAL, AND OTHER PROBLEMS

Mining. Mining problems in Slocan area are many and varied. The district is mountainous and most of the properties are situated well up on the slopes of the hills. Aerial tramways are consequently used extensively in transporting the ore from mine to mill or to railway or roads at lower levels. In the early years of mining the ore was commonly rawhided down the hills in the winter months, but this practice is now largely superseded by the use of aerial tramways. Roads and trails are plentiful and the distance from any property to railway transportation is rarely over 3 or 4 miles in a direct line and commonly much less. Good timber is not plentiful, although there is usually sufficient on hand for mine and domestic uses. Forest fires in the past have swept over most of the area, causing great losses to mining properties lying within their area of devastation. During a considerable part of each year, water is rather scarce above the main valley levels, for although the snowfall in winter is usually quite heavy the run-off is rapid in the late spring and summer months, leaving little for the remainder of the year. The main creeks, however, are mostly fed by glaciers at their head and maintain a good volume throughout the year. Owing to the steep and comparatively open slopes, snow and land-slides are of common occurrence and have caused serious destruction to life and property in the past. As a consequence, buildings, mine entrances, tramways, etc., are commonly located on spurs or interstream ridges where there is the least likelihood of accidents of this character.

Milling. Owing to the complex character of the ores, milling was early regarded as essential to the economic extraction of the ore minerals and the separation of the zinc from the silver-lead ores. Alamo mill, built in 1894 but now entirely reconstructed, was the first to be erected, and was followed by the Washington in 1895, the Slocan Star and Noble Five in 1896, and by some fifteen other mills since that time. The older mills have all been dismantled or destroyed and their place, in most cases, taken by more modern structures. The latest, or "Davys mill" of Metals Recovery, Limited, a private company of five including M. S. Davys, Kaslo, B.C., resident manager, was erected in 1924 in Kaslo Creek valley near the mouth of Lyle creek. It has a capacity of 100 tons a day and has been fitted primarily to treat the zinc ore and tailings discarded from the Whitewater mine during its early years of operation.

At the present time there are thirteen mills in the area with a total capacity of about 1,500 tons a day and an individual capacity varying from 75 to 150 tons. These mills have three important problems to contend with, namely: the separation of the ore from the gangue; the separation of the zinc from the lead ores; and the recovery of a maximum silver, lead, and zinc mineral content. Selective flotation machines have been installed in most of the mills now operating and have given satisfactory results.

Smelting. In the early years, much of the ore from this area was shipped to foreign smelters, chiefly in the United States, but some in Europe, particularly in Wales and Belgium. Prior to 1916, very little zinc ore was treated in Canada, but following the installation of an electrolytic zinc plant at Trail in 1915 advantage has been taken of the proximity of this smelter and much of the zinc, as well as the silver-lead ores from the Slocan, are now treated there.

Capital. The properties of Slocan mining area are largely controlled by United States, and particularly by Spokane, capital. Of the thirty-six properties which in the past have each shipped a total of over 1,000 tons of ore, twenty-four are at present controlled by United States and the rest chiefly by Canadian capital. Among the more important of the United States controlled properties are the Silversmith, Standard, Van Roi, Rambler-Cariboo, Hewitt, and Bosun mines. Canadian interests are concerned in such important producers, past and present, as the Payne, Whitewater, Ruth-Hope, Richmond-Eureka, Noble Five, Lucky Thought, and Molly Hughes. Developments in the last few years seem to indicate a more general willingness on the part of Canadian investors to take a hand in mining operations in this district.

Leasing. The leasing system is much in vogue in the Slocan and seems peculiarly adapted to mining conditions there. By reason of the high-grade character of the ores and their occurrence in comparatively narrow, lens-shaped shoots, companies have often found it to their advantage to work out the bulk of a shoot and continue investigations for others, leaving the more restricted parts of the ore-bodies to be worked out by leasers who can employ more economical methods of stoping, to the mutual advantage of both themselves and companies. Royalties are paid from the smelter returns on the ore shipped. The terms of the contract under which the leasers work, vary in different properties, depending among other factors on the location of the property, the facilities for handling and milling the ore, and the amount of development work called for. When the terms of the contract are strictly adhered to there is much in favour of this system, but in other instances it results in much harm to the property through careless distribution of waste and negligence in the repair and upkeep of the underground workings.

Geology. The geology of the area has been reported upon in a general way in previous reports of the Geological Survey (*See* Bibliography). The principal metallized sections are underlain by a sedimentary series of argillites, slates, quartzites, and limestones, including all gradational types. These sediments have been referred to in the past as belonging to the Slocan series. Fossil collections made last summer from the vicinity of the Whitewater and Lucky Jim mines and from the upper southeastern slopes of Schroeder and Jardine mountains were determined by F. H. McLearn as Mesozoic. It thus is possible that the entire Slocan series is of Mesozoic rather than, as heretofore supposed, of Palæozoic age. The finding of these fossils affords an explanation of the apparent conformity between the Slocan and Milford series,[1] the latter of which has been regarded as of probable Jurassic age. The sedimentary areas are flanked on the south by later granitoid rock of the Nelson batholith and are penetrated here and there by stocks, probably related to this batholith, and mostly less than a square mile in areal extent. The sediments are all more or less deformed and metamorphosed. They have a general northwesterly strike and dip at high angles to the southeast or northeast. In addition to the Nelson batholith and its satellitic stocks, the sediments have been intruded by a multitude of dykes varying in width from a foot or two, to several hundred feet. They include both acid and basic types, of which the former are much the more abundant. The dykes are most numerous at a distance of a mile or more from the batholithic contact and it is at this distance too that the greater number of the ore deposits occur. The dykes strike in every direction, but the majority of them rather closely parallel the strike of the enclosing sediments and in this respect resemble sheets or sills rather than dykes.

Ore Deposits. The ore deposits of the Slocan may be most conveniently classified according to their composition, by which classification they are divisible into two important types with others of lesser significance. The important types are commonly referred to as "dry" and "wet" ores, the latter constituting the predominating type. The "dry" ores are quartz veins or veins in which the predominating gangue is quartz. The chief values in these ores are in silver with subordinate lead and zinc and in some cases gold. The silver values are carried mostly in silver minerals present in, or associated with, galena and zinc blende. The veins occur in or close to granitic intrusives and are generally regarded as having formed

[1]Bancroft, M. F.: Geol. Surv., Canada, Sum. Rept. 1919, pt. B, p. 43.

under somewhat higher temperature conditions than the "wet ores." Examples of "dry" ore veins occur on the Molly Hughes, McAllister, Silver Glance, Mowitch, Flint, and Mountain Con properties.

The "wet" ores are composed essentially of galena, associated with more or less blende. The chief, and characteristic, gangue mineral is siderite (spathic iron), but some quartz and, more rarely, calcite may be present. The proportion of gangue to ore minerals is much lower in the "wet" than in the "dry" ores.

High-grade silver-bearing minerals, of which the most noticeable is grey copper,[1] are commonly associated with the galena in both "wet" and "dry" ores. Other minerals such as native silver, argentite, the ruby silvers, chalcopyrite, and pyrrhotite, may be also found in varying combinations in these deposits. Pyrite is always present and increases in amount in depth. Gold is usually absent or present only in minute proportions, but in a few properties such as the Molly Hughes, Monitor, Capella, and Mowitch, it is an important constituent. Copper, also, is rarely present in commercial quantities, but in 1903 some 180 pounds was recovered from the Rio and in 1906 shipments from the Idaho-Alamo included 2,860 pounds.

In addition to the wet and dry ores in which the values are in silver, lead, and zinc, there is one gold property on Lyle creek, the Phoenix;[2] two manganese properties[3] on the east side of Kaslo creek above Zwicky; and one arsenic-gold property, the L. H.,[4] in the southwest corner of the area. There is also one copper property, the True Blue, southwest of Kaslo, and one antimony property, Alps Alturas, north of the area in the basin of Kane (North fork, Carpenter) creek, both of which lie outside the limits of the area proper. Both of these properties have shipped some ore; the True Blue some 64 tons in 1902 carrying 1 ounce of gold, 109 ounces silver, and 9,479 pounds copper; and the Alps Alturas some 27 tons in 1916 yielding 31,436 pounds of antimony. A sample of pyritized quartz from the vein on the Phoenix property, mentioned above, was assayed by the Mines Branch, Ottawa, and found to contain gold at the rate of 0·63 ounce to the ton.

The ore deposits of the area are regarded as owing their occurrence and extent to two processes, fissuring and replacement. Of these processes fissuring may be regarded as the more important factor in determining channels for the original incursion of metalliferous solutions. The term "fissure vein" as used in this area includes not only open fractures subsequently filled by vein minerals, but, also, lines of major jointing along which very little open fracturing existed, and broad zones of more or less intense shearing and faulting whose position may have been influenced to some degree by pre-existing fissures but in which this condition has been partly or entirely obscured by later movement. Shearing and faulting partly preceded and partly followed the early invasion of ore-bearing solutions and have been more or less active since that time. They have resulted in the brecciation of the earlier formed minerals and in their

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[1]The term "grey copper" is used in this report to include either the polysulphide of copper and antimony "tetrahedrite," or the gradations to the argentiferous polysulphide of the same metal "freibergite".
[2]Bancroft, M. F.; Geol. Surv., Canada, Sum. Rept. 1917, pt. B, p. 33.
[3]Bancroft, M. F.: Geol. Surv., Canada, Sum. Rept. 1917, pt. B, pp. 29-33.
[4]Bancroft, M. F.: Geol. Surv., Canada, Sum. Rept. 1917, pt. B, pp. 33-35.

cementation, in part by later mineralizing solutions and, in part, by re-arrangement under conditions of stress, of less resistant minerals such as galena and calcite. Depending, too, upon a number of factors such as the composition of the rocks traversed, the degree of brecciation of the wall-rocks, and the facilities afforded for escape of the ascending solution, there has been a greater or lesser replacement of the wall-rock on either side of the original line of fracture.

The ultimate origin of the ore deposits can be referred to the granitic rocks of the Nelson batholith which flanks the area to the south and from which many apophyses, like huge tongues, project northward into the older rocks. In all probability these batholithic rocks underlie the whole metallized area and to them are, doubtless, related the several stocks which here and there project through to the present surface. The numerous acid and basic dykes of the area are, with a few exceptions, also, in all probability, closely related to the batholith intrusives. The relation of these major intrusive bodies to the ore deposits is evidenced in two important particulars, namely the occurrence of ore deposits in the batholithic rocks themselves, and the appearance of a zonal distribution of metalliferous and gangue minerals with regard to the batholith. In or near the batholith the ores are predominantly of the "dry" type with abundant quartz gangue and a comparative sparsity of galena and blende. Farther from the batholith the proportion of galena and blende to gangue matter increases and the place of quartz is taken by an increasing proportion of the iron carbonate siderite (spathic iron), the predominant gangue mineral of the silver-lead and zinc deposits of the Slocan.

The changes in vein composition are referable to the decrease in temperature as the distance from the source of the mineralizing solutions increases. The change bears a distinct relation to the distance from the batholith and is in evidence, not only over distances measured laterally from the batholithic exposures, but is noticeable in developments at depth on individual veins and ore-shoots. Where the upper parts of the vein deposits are composed chiefly of galena, the place of this mineral is partly taken, as depth is attained, by an increased proportion of zinc blende and siderite gangue. At greater depths the galena is subordinate to the blende, with siderite still the chief gangue mineral. At still greater depth the proportion of blende decreases and siderite, with or without quartz, may form most of the vein matter. At even greater depth quartz may represent almost the entire vein filling, in which case the vein takes on the appearance of a "dry ore" in which more or less high-grade silver minerals, pyrite, and specks of zinc blende or galena may represent the only ore minerals.

There are, of course, important exceptions to this order of deposition, but they serve rather to emphasize the rule than to discredit it. Exceptions occur on several properties in the area where the vein or vein system is broad and strong and marks the site of more or less severe brecciation and movement. As a result of the opening up of the fissures by these movements an opportunity has, in some instances, apparently been afforded for later incursions of metalliferous solutions. Such later solutions would tend to cool at a greater distance from the surface than the first and, in consequence, the galena, zinc blende, etc., might be expected to be deposited at lower points in the vein than in the case of the first incursion. Such circumstances may account for the discovery of different shoots of silver-lead ore as depth on the vein is attained. On the other hand, where there is little or no evidence of brecciation or movement and where the vein matter is composed only of zinc ore, or of zinc blende associated with spathic iron or quartz, the rule seems to apply and the likelihood, in such instances, of obtaining silver-lead ore at greater depth on the vein is small.

The fissures predominantly strike northeast-southwest, whereas the general strike of the bedded rocks is northwest-southeast. There are, for example, thirty-six properties that in the past have each shipped over 1,000 tons of ore and the productive veins on nine of these properties strike almost exactly northeast and southwest; on twelve others the average strike is within 10 degrees and on three others within 20 degrees, of this direction. Of the remaining twelve properties only three have developed important veins, whose strikes lie in the northwest and southeast quadrants. These three, together with two other properties on which the vein strikes nearly east and west, are, likewise, the only properties of the entire thirty-six on which the vein dips in other than a south-easterly or southerly direction. This dominant northeasterly trend is not characteristic of any particular locality, but is noticeable in all the more important metallized centres, as well as in the less productive parts of the area. Where the deviation from this trend is most marked it was generally found that the veins were strong zones of shearing, corresponding, rather closely, in position to the strike of the enclosing sediments. The more pronounced zones of shearing and faulting commonly follow or rather closely follow the strike of the sedimentary rocks, but it is, apparently, only where the direction of this shearing swings from its general northwesterly trend to a more easterly or northeasterly position that such lines of weakness afforded favourable channels for metalliferous deposition.

The courses of the northeasterly trending, southeasterly dipping fissure veins have been, however, more commonly controlled by a master system of jointing along which very little movement has occurred. Fissures controlled by this joint system are characteristically straighter than those whose position has been influenced by rock structure and shearing, but are commonly accompanied along their course by jogs to the right or left to meet other parallel fissures along which the vein matter continues. These jogs are rather important in mining practice. They represent faults or slips running out from either the foot- or hanging-wall, but rarely crossing both. As a rule they represent no great displacement, but are vexatious to the operator until he learns the "system" which they follow. In general, for any particular property and in any particular vicinity where the dip of the sediments is in one direction, these jogs are either all "right" or all "left" jogs depending, apparently, upon whether the dip of the sediments is in a southerly or northerly direction.

These slips should not be confused with the cross-fractures or fissures commonly referred to as "feeders" and which have been one of many favourable factors in ore deposition. Like the slips previously referred to they may run into the main vein from either foot- or hanging-wall side, following bedding planes, planes of schistosity, and joint or other lines of weakness. These cross-fissures do not effect any displacement in the main vein and very often contain a little ore for some distance out from the wall of this vein. In some cases, where they are unusually strong and their angle with the main vein not very great, it is easy for the operator to confuse the two, particularly where the main vein is itself somewhat irregular in strike. In certain cases, as on the Last Chance and Slocan Star veins, such cross-fissures have been developed for a considerable distance from the main vein and have produced some good ore.

The above distinctions in the vein structures are complicated by other considerations, among which the character and composition of the enclosing rocks are important factors. Other things being equal the more fissile the sediments the greater the width of sheared matter constituting those veins which follow or cut at a small angle across them. And again the more calcareous the sediments the greater importance replacement has in determining the width of the ore-body at any particular point. Thus a true fissure vein, though in itself narrow, cutting across a thick bed of limestone, as at the Lucky Jim mine, may develop larger ore-bodies by replacement on one or both sides of the fissure than a sheared fissure following or closely in line with the strike of massive argillaceous or quartzitic sediments where replacement is a comparatively difficult process.

The composition of the country rocks, in so far as it governs their relative susceptibility to replacement, is an exceedingly important factor in Slocan metallization, and it seems likely that replacement has played a much more important role [1] in the development of Slocan ore-bodies than has hitherto been generally recognized. The process of replacement is assisted by the two principal factors indicated above, namely: the limy composition of the enclosing rocks and the extent to which they have been brecciated prior to or during the period of metallization. In addition to the widely distributed, fairly numerous, distinct limestone beds among the sedimentary members of the Slocan series a notable proportion of the other members are more or less calcareous. Instances have been noted on certain properties where wider parts of the ore-bodies are associated with such calcareous beds and it is not unlikely that a more detailed study of rock composition in other properties would result in a like discovery.

Another important feature of the ore deposits in this area relates to the abundance of dykes occurring in the chief centres of metallization. The mere association of these dykes with the ore-bodies is in itself suggestive of some relation between the two. The dykes include both acid and basic types, of which the former are the more abundant. The two are probably complementary in their origin. The acid types vary from aplite to quartz diorite porphyry and have not been observed cutting the batholithic rocks in the area. The basic dykes are lamprophyre types. They cut the batholithic rocks and at different properties in these rocks (Fisher Maiden and Mountain Con) appear to have exerted an important localizing effect on the ore deposits. In general, the dykes show a tendency to follow the bedding planes or planes of schistosity of the enclosing rocks, although some dykes very definitely cut across them. Both acid and basic types

[1] Bateman, Alan M.: Econ. Geol., vol. XX, No. 6, p. 571.

are regarded as having been intruded at about the same time and, as in several cases the fissure veins cut directly across them and form ore within their boundaries, the period of metallization is regarded as being somewhat later. Consequently, it cannot be assumed that the dykes are directly responsible for the ore-bodies. It is not unlikely, however, that no great interval of time elapsed between the intrusion of the batholithic and dyke rocks of the area, and the incursion of metalliferous solutions. This interval was characterized by abundant fissuring. More or less fissuring may also have antedated the period of dyke intrusion and much of the shearing and faulting in the area probably extended over a still longer period, beginning before the dykes were intruded and continuing long subsequent to their consolidation. Lines of weakness provided by such early movements and fissuring afforded convenient locations for dyke intrusion and except where the sediments themselves were of a fissile or schistose nature it is difficult to conceive of these dykes of uniform width and great length forcing their way through the overlying strata without some pre-existing line of weakness controlling their position. Nor were these lines of weakness, in many cases, completely healed by these intrusions. Subsequent movements commonly followed along the lines taken by the dykes, as is evidenced by their abundant shearing in the underground workings of such mines as the Bosun, Jackson, etc. Such post-intrusive movements provided convenient channels for ore-bearing solutions and in those cases where the fissure vein deposits are located along or more or less in line with dyke intrusions a search for new ore veins or ore-bodies is coincident with a further exploration of the course of these dykes.

Aside from this important relation of dykes to fissures, and fissures to ore-bodies, the dykes appear to have exerted an important influence in localizing the mineral deposits in one or more of the following ways: by deflecting the mineralizing solutions into certain channels or particular sections of a channel; by restricting the flow of solutions within more massive and less fractured walls, and thereby influencing concentration in intermediate stretches of country rock where the fissured zone was broader and the country rocks more susceptible to replacement and filling processes; by forming a more or less impervious wall against which the ore and gangue minerals tended to bank and concentrate; by deflecting the course of a fissure or fissures along the course of a dyke; and by creating new, or accentuating old, lines of weakness at the time of their intrusion—these lines of weakness bearing some proportion both in strength and number to the abundance of dyke intrusions and, to a similar degree, creating a favourable condition for subsequent metallization.

Ore-shoots. The values in Slocan vein deposits are most commonly concentrated in ore-shoots. These shoots have a general elliptical outline with a thickness that is small as compared with their other dimensions. The intervals between ore-shoots on any particular vein are usually much greater than the length of the shoots themselves, the vein filling in these intervals being composed essentially of broken or crushed wall-rock partly cemented by gangue minerals and including small bunches or disseminated grains of metallic minerals. The ore-shoots rarely pitch or dip with the ore veins, but have a pronounced rake across them. It has been the common experience to find one main ore-shoot on each vein, with others of minor importance on either side of it. Examples of such major shoots occur on the Standard, Queen Bess, and Payne properties. In certain veins or vein systems, however, such as the Silversmith–Slocan Star-Richmond Eureka vein, and Van Roi-Hewitt vein, two or more major shoots may occur and it is not unlikely that important ore-shoots will be proved on further investigation to occur on veins whose continuity from one property to another has not yet been established.

The very noticeable fact that the ore favours different types of rock in different localities is of importance locally and should not be overlooked. Its significance, however, is not easily explained and must be viewed in the light of a number of factors, including such considerations as rock composition and structure and the influence of dykes on the localization of ore-bodies.

In the average ore-shoot the galena bands or lenses tend to favour the hanging-wall, with blende and finally gangue minerals occupying the lower side of the vein. Subordinate bands or streaks may, however, occur along the foot-wall and it is not uncommon, in the more fractured veins, to find the galena occurring in comparatively narrow and nearly parallel cross-fractures running from wall to wall through the more massive zinc blende and gangue. In the larger veins solid galena in places occupies a width of several feet and many small veins up to a foot in width are composed entirely of this mineral. Very commonly, too, in the wider vein systems, there may be pronounced hanging-wall and foot-wall fissures containing good ore with several feet of waste between. In such cases the walls of either fissure, though probably well defined, are only apparent and adjacent ore-bodies may be present.

The ore-shoots are usually of complex composition. They may be composed of irregular bunches, bands, or lenses of galena, overlapping or en échelon, and surrounded or flanked on one or both sides by crushed country rock, or by seams of gouge from a mere film to several feet in thickness, or by bands of zinc blende, spathic iron, or (and) quartz. The pay-streak may or may not be well defined, or the lead ore may be intimately distributed through a vein filling composed of zinc blende, gangue minerals, and crushed fragments of the wall-rocks.

RECONNAISSANCE IN THE PURCELL RANGE WEST OF BRISCO, KOOTENAY DISTRICT, B.C.

By John F. Walker

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INTRODUCTION

Part of the season of 1925 was spent by the writer in making a reconnaissance survey along the east slopes of the Purcell range between latitudes 50° 41′ and 51°. The area forms part of Windermere and Golden mining divisions, Kootenay district, southeastern British Columbia.

Mr. J. R. Pollock rendered efficient assistance in the field.

Prospectors entered this area in 1883 and that year silver-lead claims were staked on Spillimacheen (formerly called Spallumcheen) river. Interest lapsed until the years 1888 to 1891 when Jubilee and Spillimacheen mountains were thoroughly prospected. After a further lapse of nine years, prospecting again became active and claims were staked on Bugaboo and Frances creeks. Since 1900 attention has been confined to the old prospects, no new locations of note having been made. The British Columbia Minister of Mines reports for the years 1883, 1888 to 1891, 1895, 1898, and 1900, to the present, mention the various prospects within the area. Dr. F. P. Shepard[1] made some geological observations on Jubilee, Spillimacheen, and Steamboat mountains, this being the only geological work done within the area other than that by the Resident Engineers of the British Columbia Mines Department.

[1]Shepard, F. P.: Jour. Geol., vol. XXX, fig. I, p. 362 (1922).

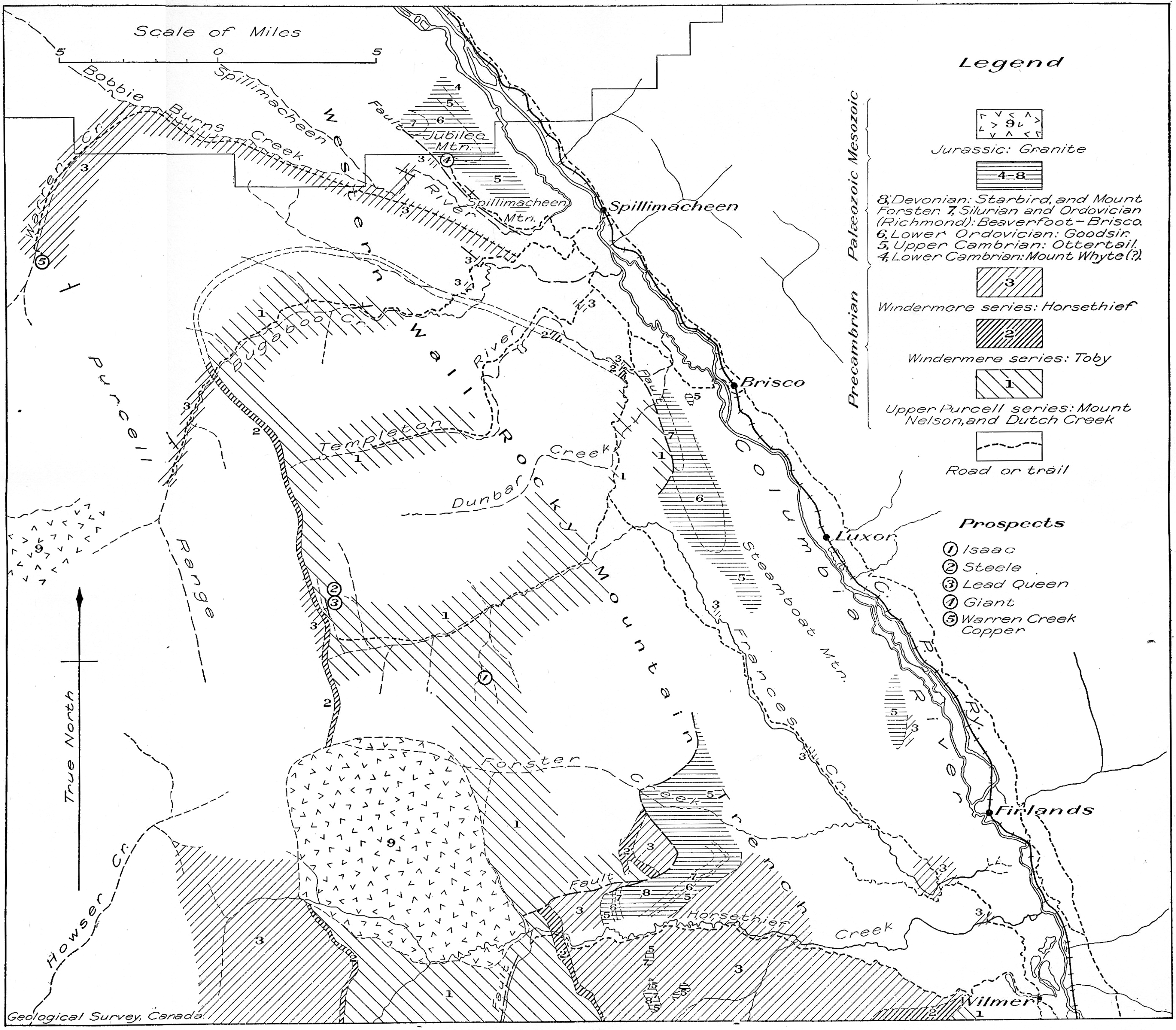


FIGURE 13. Index to the geology of parts of Golden and Windermere mining divisions, Kootenay district, B.C.

GENERAL CHARACTER OF THE DISTRICT

The district is reached by road and trail from the towns of Spillimacheen and Brisco, on the Kootenay Central branch of the Canadian Pacific railway. A fair wagon road runs south from Spillimacheen, along the valley to the west of Steamboat mountain, to Wilmer and Athalmer at the north end of lake Windermere. A branch road connects with Brisco and others follow Frances, Bugaboo, and Bobbie Burns creeks, the two latter being fit only for pack horses. There is a fair trail up Templeton river and a poor one up Forster (formerly known as No. 2) creek.

The area lies on the eastern slopes of the Purcell range and extends from the summit of the range eastward to the Rocky Mountains trench. The trench is divided longitudinally by the long ridge of Steamboat mountain which rises to an elevation of 6,000 feet at its north end. The eastern part of the trench is followed by the northward-flowing Columbia river, with an elevation of about 2,560 feet above sea-level. The western part, through which flows Frances creek, has an elevation of 3,000 to 3,800 feet. The western wall of the trench rises abruptly to elevations of 6,000 to 8,000 feet, but in the northern part of the area is pierced by the broad valley of Spillimacheen river which cuts it at an acute angle. North of Spillimacheen river and the low saddle north of Jubilee mountain the western wall continues as the eastern face of Dogtooth range.

Bugaboo, Templeton, Dunbar, Frances, and Forster creeks have cut deep valleys back into the range. The gradient of these creeks near their source is very steep, but gentle in their lower course. These creek valleys make great gaps in the wall of the trench. The ridges between them average between 8,000 and 9,000 feet in elevation. They are dissected by many cirque basins from which small steams plunge precipitously into the larger creeks. Bugaboo creek has eroded its way around the head of Templeton river and rises near the source of Frances creek.

Most of the timber on Frances and Bugaboo creeks has been destroyed by fire and there is little of value on Templeton river. Forster creek is fairly well wooded, as is also Steamboat mountain. The trees along the valley west and north of Steamboat mountain are, in places, set well apart and the country is park-like. These areas, with their numerous sloughs and small lakes, make good range for cattle. There are small areas of bottom land along Frances creek, west of Steamboat mountain, suitable for agriculture.

GENERAL GEOLOGY

The eastern slopes of the Purcell range are carved in Precambrian sediments that belong to the Upper Purcell and Windermere series, separated by a marked unconformity. Palæozoic sediments form the greater part of Steamboat mountain and outcrop on the wall of the trench north and south of Forster creek. Isolated outcrops of the Precambrian occur along the trench to the west of Steamboat mountain. A granite area extends north from Windermere map-area to the head of Forster creek, and another lies west of the headwaters of Bugaboo creek.

Table of Formations

Era	Period	Formation
Quarternary..........	Recent..........................	Alluvium
	Pleistocene..........................	Sills, gravels, till
	Unconformity	
Mesozoic..............	Jurassic (?)..........................	Granite stocks
	Intrusive contact	
Palæozoic.............	Devonian..........................	Mount Forster and Starbird
	Upper Ordovician and Silurian......	Beaverfoot and Brisco
	Lower Ordovician..................	Goodsir
	Upper Cambrian....................	Ottertail
	Lower Cambrian....................	Mount Whyte (?)
	Unconformity	
Late Precambrian.....	Greenstone dykes	
	Intrusive contact	
	Windermere series..................	Horsethief Toby
	Unconformity	
	Upper Purcell series.................	Mount Nelson Dutch creek

LATE PRECAMBRIAN

Upper Purcell Series. The Mount Nelson [1] and Dutch Creek[2] formations are the only members of the Purcell series exposed within the area. They form the Upper Purcell series and occupy a belt along the eastern part of the Purcell range from Windermere map-area north to Bugaboo creek. Between Bugaboo and Bobbie Burns creeks the series plunges to the north beneath the Windermere series. On the north end of Steamboat mountain and across Forster creek the series is thrust over the Palæozoic formations.

The greater part of the Precambrian strata in the area belongs to the Mount Nelson formation, which has an estimated thickness of about 3,000 feet of vari-coloured magnesian limestone, slate, and quartzite,

[1] Geol. Surv., Canada, Mem. 148, p. 10.
[2] Geol. Surv., Canada, Mem. 148, p. 7.

weathering to a rusty brown. The Dutch Creek formation is chiefly grey slate, of which some 2,000 feet is exposed. It does not show the rusty weathering of the Mount Nelson formation.

Windermere Series. Most of the exposures of the Windermere series are along the western side of the area. It forms a belt along the east side of the summit of the range from Windermere map-area north to Bugaboo creek, where it swings to the east around the plunging Purcell series. It outcrops along Bobbie Burns creek and along the western part of the trench as far as Templeton river; on the south end of Steamboat mountain where it is overlain by the Ottertail formation; and along the lower reaches of Frances and Forster creeks. It is probable that more detailed work will show areas on the high ridges between Forster creek and Templeton river.

The series includes the Toby conglomerate[1] which rests with marked unconformity on the Purcell series, and the Horsethief formation which conformably overlies the conglomerate. The Toby conglomerate is an unassorted piedmont deposit varying in nature and thickness. It is made up of angular and subangular fragments of limestone, quartzite, and slate up to 4 feet in diameter, in a matrix which may be either calcareous, siliceous, or argillaceous. In Windermere map-area to the south, the thickness varies from 50 to 2,000 feet. The Horsethief formation overlies the Toby and is essentially slate. The slates are mostly grey and fine-grained. Several interbeds of coarse quartzite, fine pebble conglomerate, and limestone occur in the slates. The formation is approximately 5,000 feet thick.

Greenstone Dykes. These dykes, so common in Windermere map-area to the south, are found at only a few places to the north. They are altered to chlorite schists, cut the two Precambrian series, and are believed to be Precambrian in age.

PALÆOZOIC

Mount Whyte Formation (?). The Lower Cambrian[2] outcrops on the northeast side of Jubilee mountain where it is overlain by the Ottertail formation.

Ottertail Formation. The Upper Cambrian Ottertail formation forms the greater part of Steamboat mountain and also outcrops on the west wall of the trench to the north and south of Forster creek. It rests with slight angular unconformity on the Horsethief formation and is overlain by the Goodsir formation. It is a magnesian limestone, light grey, massive, and cliff-forming. Its thickness on Steamboat mountain is about 1,500 feet, but it thins rapidly to the southwest to about 1,000 feet on the ridge north of Forster creek and to 600 feet on the north side of Horsethief creek in Windermere map-area. The Precambrian is thrust over the Ottertail on the north end of Steamboat mountain and on both sides of Forster creek.

Goodsir Formation. The Goodsir formation, in part Lower Ordovician and in part Upper Cambrian in age, outcrops on the north end of Steamboat mountain. It rests conformably on the Ottertail and is overlain by the Richmond. It has an estimated thickness of 2,500 feet on the north end of Steamboat mountain, but thins rapidly to the southwest to 70 feet on the north slope of Horsethief creek. It is cut out on the wall of the trench

[1] Geol. Surv., Canada, Mem. 148, p. 13.
[2] Report in preparation by Mr. C. S. Evans.

north of Forster creek by the thrust which carries the Precambrian over the Ottertail. A remnant may exist on the timbered slope of the north side of Forster creek. The formation is made up of grey shale and thin-bedded, bluish grey limestone which is more in evidence in the upper than in the lower part of the formation. The limestone is fossiliferous.

Beaverfoot-Brisco Formations. These formations, which include the Richmond and Silurian, on the east side of the trench, have not been differentiated within the district. Outcrops on Jubilee and Steamboat mountains and on both sides of Horsethief creek are from the base of the formations and probably represent only the Richmond.[1] The beds are massive, dark grey, magnesian limestone. They rest with seeming conformity on the Goodsir formation and are overlain by Devonian rocks.

Mount Forster and Starbird Formations. These formations[2] occupy only small areas on the north and south sides of Horsethief creek within Windermere map-area.

MESOZOIC

Jurassic (?): Granite Stocks. The granite stock at the head of Horsethief and Forster creeks is a medium-grained, microcline granite, poor in ferromagnesian minerals. It is homogeneous and generally porphyritic. The phenocrysts range in size up to 1½ inches, are microcline, and in many cases show zoning. The walls of the stock are steep, and contact phenomena are not pronounced. Mineralization appears to bear no relation to this stock, but is presumably derived from the parent body of the stock.

The granite area at the head of Bugaboo creek was not examined, but float from it is similar to that of the Horsethief stock.

QUATERNARY

Glacial silts and gravels cover the greater part of the floor of the trench. They have been deposited by lateral streams, issuing from glaciers and emptying into a lake[3] which occupied the trench on the retreat of the continental ice-sheet. The river which occupied the valley after the breaching of the dam that held in the lake, has cut wide terraces in the silts. These terraces have since been dissected by lateral streams and rain wash.

Till in some places overlies the gravels and silts.

Recent alluvium is found along the central depression of the trench occupied by Columbia river and has been formed by the river overflowing its channel in periods of flood.

STRUCTURAL GEOLOGY

The structure of this part of the Purcell range is a continuation of that to the south. It is a great, north-pitching arch made up of several anticlinoria and synclinoria. The Lower Purcell series passes under the Upper Purcell series in the region of Skookumchuck creek, 45 miles south of Forster creek. Between Bugaboo and Bobbie Burns creeks the Upper Purcell passes under the Windermere series.

[1]A more detailed report on these formations is being prepared by Mr. C. S. Evans.
[2]Geol. Surv., Canada, Mem. 148, pp. 34, 35.
[3]Geol. Surv., Canada, Mem. 148, p. 37.

The greatest fault in the area—the thrust crossing Forster creek—carried the Precambrian over the Palæozoic. The thrust on the north end of Steamboat mountain shows the same phenomena and appears to be a continuation of the one on Forster creek. The northward extension has not been definitely traced, but it is probable that it passes immediately west of Spillimacheen mountain. The thrust dies out near Jumbo creek in Windermere map-area to the south. The maximum horizontal displacement is estimated as about 2 miles in the region of Forster creek and is from northwest to southeast.

Many small faults occur in association with the folding, and generally have a high angle.

Steamboat, Spillimacheen, and Jubilee mountains are synclinal, with steep upturns toward the west.

ECONOMIC GEOLOGY

The economic deposits along the slopes of the Purcell range within the area are small lead-silver fissure veins, associated in origin with the close folding and fracturing of the Mount Nelson limestones. The Lead Queen, Steele, and Isaac deposits are of this type.

Several prospects have been located in the Palæozoic limestones on Spillimacheen and Jubilee mountains. They are chiefly barytes veins and replacements, carrying small amounts of sulphide and occurring in the Ottertail limestone. None of the gold and copper deposits so far found is of any economic importance.

DESCRIPTION OF PROPERTIES

LEAD QUEEN

This property is situated at an elevation of 7,700 feet in a basin on the north side of and near the head of Frances creek. The property is reached by road, extending 18 miles from Brisco to an elevation of 6,400 feet, and thence by a rawhide trail to the upper camp at 7,100 feet and to the workings half a mile distant at 7,680, 7,750, and 7,890 feet. The adits at 7,680 and 7,750 feet were snowed under at the time of the writer's visit in July. A description of them is given in the report of the Minister of Mines, British Columbia, 1915. The vein, a true fissure in limestone, outcrops at 7,890 feet. It strikes 338 degrees and has a high dip to the southwest. It shows for several hundred yards along the east side of the basin and cuts across towards the Steele basin to the north. The vein pinches and swells and shows a few inches of galena at intervals. An adit was driven near the upper camp to cut the fissure about half a mile from the upper workings, but failed to do so.

STEELE

This property is situated at an elevation of 8,350 feet in a basin northeast of the Lead Queen basin. The upper camp at 7,850 feet is reached by rawhide trail from the Lead Queen road.

The workings are on the precipitous side of the basin west of the camp. An aerial tram, in disrepair, reaches from the workings to a point near the camp. The property is located on what is probably the northern extension of the Lead Queen fissure. The fissure, in limestone, is on the west side of an anticlinal fold. Specimens of sacked ore were polished and examined under the metallographic microscope. The ore has a gneissic structure and shows replacement of crushed carbonate gangue and pyrite, by sphalerite, galena, and tetrahedrite. The latter minerals appear to be contemporaneous and do not exhibit crushing, but show a gneissic structure suggesting deposition under differential pressure. Some of the tetrahedrite is argentiferous and reacts to potassium cyanide in the polished specimens.

ISAAC

This property is situated at an elevation of 7,900 feet on the precipitous side of a basin on the south side of Frances creek about 3 miles by rawhide trail from the 13-mile on the Lead Queen road from Brisco. The camp is at an elevation of 7,300 feet. A light tram drops the ore to a point on the trail just above the camp. The property is on a fissure in the Mount Nelson limestones. The fissure strikes 312 degrees and dips 65 to 70 degrees to the southwest. The sediments to the north of the workings strike about 35 degrees, and south of the workings 335 degrees, and the dip is vertical. The fissure shows mineral for about 350 feet south of the workings. The maximum width seen on the surface was 18 inches. Galena is the principal sulphide, with small amounts of pyrite. A greenstone dyke to the south of the outcrop is of the Purcell type and older than the mineralization.

GIANT

This property is situated at an elevation of 3,520 feet on the northwest slope of Spillimacheen mountain, and is about 6½ miles by road from Spillimacheen. The property is on a barytes vein which carries small amounts of sulphide and cuts the Ottertail limestone. The workings are close to the contact of the Ottertail with the Goodsir. The vein is 30 feet wide in an open-cut, strikes 300 degrees, dips 54 degrees southwest, and outcrops for several hundred feet up the hill-side. The sulphide is fine-grained galena and is in scattered bunches in the barytes. A brief account of the work done on the property is contained in the Report of the Minister of Mines, British Columbia, 1923.

HIDDEN TREASURE

Above the Giant at an elevation of 4,350 feet is the Hidden Treasure. An open-cut shows a small lens of barytes with some copper stain. Numerous prospect pits on the top of Spillimacheen mountain show barytes and a little sulphide, the barytes being in the form of veins and replacements in the Ottertail limestone.

WARREN CREEK COPPER PROSPECT

This is situated on the east side of Warren creek at an altitude of 6,750 feet and 600 feet above the creek bottom. The prospect is 24 miles by road and trail from Spillimacheen. The vein strikes 325 degrees and dips 80 degrees to the southwest and has a maximum width of 10 inches of chalcopyrite. It outcrops for a little over 100 feet and is in dark grey slate of the Horsethief formation.

FUTURE POSSIBILITIES

The future of the area from the standpoint of mining is dependent on the discovery of new properties. None of the old properties shows promise of being more than a small producer. The most favourable areas for prospecting are limestone exposures of the Mount Nelson formation. The possibility of discovering mineral in economic quantities in the Ottertail formation on Steamboat, Spillimacheen, and Jubilee mountains is not so promising as in the case of the Mount Nelson formation to the west, but any discoveries there made would be comparatively near adequate transportation facilities.

KNOPITE AND MAGNETITE OCCURRENCE, MOOSE CREEK, SOUTHEASTERN BRITISH COLUMBIA

By H. V. Ellsworth and John F. Walker

During the second week of July, 1925, the junior author made a preliminary examination of a reported occurrence of titanium-bearing mineral on Moose creek, southeast from Leanchoil on the main line of the Canadian Pacific railway. The occurrence is 26 miles by trail from Leanchoil.

Knopite, a titanium-bearing mineral, occurs in small bunches, up to 2 or 3 inches in diameter, in a fairly coarse basic pegmatite composed essentially of hornblende, biotite, and magnetite. The knopite forms a very small percentage of the rock-mass. The pegmatite outcrops at an elevation of 8,500 feet on the ridge between Moose creek and the west branch of Vermilion river. It is lenticular, 30 feet wide, and appears to be intrusive. The presence nearby of numerous finer grained dykes of similar composition, but in which no knopite has been observed, also suggests that the coarser lens is intrusive and not a segregation. The pegmatite occurs in transition-type alkaline rocks as mapped by J. A. Allan.[1]

Recently a large body of iron ore has been reported as occurring on Moose creek, but no claims other than those covering the pegmatite and immediately adjacent ground are known to have been recorded. The magnetite seen forms only 10 to 15 per cent of the small pegmatite lens. The percentage of magnetite in the finer-grained dykes is also small. The only knopite and magnetite "float" found on the eastern side of the headwaters of Moose creek was traceable to the pegmatite outcrop. It is possible that the reported occurrence has reference to the large area of basic rock at the head of Moose creek that contains as much as 14 to 15 per cent magnetite.[2]

In 1925 a small specimen of mineral was sent to the Geological Survey by Mr. John D. Galloway, Provincial Mineralogist, B.C., on behalf of Mr. W. H. Smith of Golden, B.C. The specimen was said to be from the neighbourhood of Moose creek, Kootenay district, B.C. Preliminary tests indicated the presence of rare earths, besides large amounts of lime and titanium. The sample, therefore, was considered worthy of more detailed examination and a complete chemical analysis was made by the senior author.

The specimen was an irregular fragment the size of a small walnut, and to the unaided eye had almost the appearance of a piece of magnetite, except for a somewhat more brilliant lustre. Under the microscope small

[1]Geol. Surv., Canada, Mem. 55, 1914, and Map 142 A.
[2]Allan, J. A.: Geol. Surv., Canada, Mem. 55 (1914).

grains were dark brown and almost opaque, with high index. As magnetite was found to be present, part of the specimen was reduced to minus 60 mesh powder and separated by a strong magnet. The magnetic part made up 14·32 per cent of the total, and analysis showed it to contain 15·20 per cent TiO_2.

The non-magnetic part contained in addition to the chief mineral a few small grains of rock minerals such as mica, plagioclase, and possibly nepheline. Analysis yielded the following results. Typical analyses of Swedish knopite are included for comparison.

Analysis of Knopite

—	Moose creek, B.C.	Sweden	
CaO	35·10	26·84	32·84
TiO_2	54·49	58·74	54·52
Fe_2O_3	2·85[1]		
FeO	....	3·23	4·94
Al_2O_3	0·68		
MnO	0·08	0·31	
Ce group oxides	2·33 }		
Yt group oxides	0·05 }	5·15	4·42
ThO_2	0·06 }		
MgO	0·21	0·19	0·32
K_2O	0·07	0·75 }	1·68
Na_2O	0·46	0·29 }	
SiO_2	2·17	1·29	
SnO_2	0·04[2]		
H_2O	0·68	1·00	0·92
Ta_2O_5 }			
Cb_2O_5 }	Not detected.		
ZrO_2 }	....	0·91	
V_2O_3 }			
Total	99·27	99·41	99·64

[1]All iron as Fe_2O_3. It is probably present in the mineral chiefly in the ferrous condition.
[2]Amount too small for absolute confirmation.

The analysis indicates the similarity of the mineral to the so-called knopite which is really a ceriferous perovskite. Knopite is cited by Dana as occurring in crystalline limestone in Alno, Sweden, and the neighbouring mainland. The mineral was first described by P. J. Holmquist.[1]

A mineralographic examination of the specimen shows that it is a very intimate intergrowth of two or more minerals. The groundmass consists of an apparently quite uniform mixture of two minerals resembling remarkably an eutectic. Veinlets of magnetite penetrate the groundmass. It is assumed that the eutectic consists of knopite and a mineral having the appearance of magnetite very finely intergrown, for the supposed magnetite component of the eutectic has the same appearance under high magnification as the larger areas of definitely identifiable magnetite. A serious objection to this conclusion, however, is the fact that there appears to be more intergrown magnetite than is indicated by the results

[1]G. For Forh. 16, 73, 1894.

of the magnetic separation and the iron content of the non-magnetic part. For this reason the iron determination was very carefully checked and found correct. It may be that knopite is really an intergrowth of perovskite with some rare earth-bearing mineral in fairly constant proportions.

Another small specimen from the same locality, received about the same time as the one described, was brown in colour and more translucent under the microscope. This appears to be perovskite.

Specimens from the same locality collected during the summer of 1925 by the senior author have been only casually examined so far, but it appears that the material on the whole resembles the knopite-perovskite just described. This is, so far as known, the first occurrence of knopite in Canada.

DEEP BORINGS IN BRITISH COLUMBIA AND THE YUKON[1]

By E. D. Ingall

The Borings Division exists for the purpose of accumulating and studying records of borings made in any part of Canada, so that the information gained may be available for the guidance of drill operators and others.

An essential feature of the work consists in an exact study of samples of the strata passed through by bore-holes. In order that such samples may be as accurately representative of the strata penetrated as the drilling methods permit, it is most important that *the samples be sent direct without previous washing or other preparatory operations.* Samples should be taken at short intervals because unsuspected, important variations may exist in material appearing to be homogeneous.

Since the practical cessation about two years ago of the campaign of deep boring in the Fraser River Delta district, what little deep boring was reported has been from two places, viz: the exploration in search of petroleum on Sage creek in Flathead River valley, and the experimental borings near Armstrong in Okanagan valley and near Kamloops. The only well reported as active in Fraser River Delta area was the Empire; no direct information regarding the operations at this well has been received. The boring was rumored to have attained a depth of about 5,700 feet early in the year.

The Sage Creek boring begun about 1916 has been reported upon to a depth of 3,000 feet in a previous Summary Report.[2] Eighteen samples have since been received from the Crow's Nest Oil Company, operating at this point, and these exhibit characteristics very similar to those received in 1924, so that at the last depth shown (3,191 feet) the well seems to be still in the somewhat siliceous dolomites of the Altyn formation.

Correspondence was entered into with the Okanagan Coal, Oil, and Gas Company on receiving reports that they intended to carry on boring operations in the vicinity of Armstrong, B.C., in Okanagan valley. This company was re-organized under the name of the Armstrong Oil and Gas Company. The last news received, on September 1, reported difficulty with water and caving at 250 feet. No samples or data have since been received. A report and log was received of a boring to a depth of 717 feet located on L.S.D. 5, sec. 36, tp. 19, range XVIII, W. 6th mer., by the Kamloops Natural Gas, Oil, and Coal Company, but no official reports were received from this company. These borings being in a district where very little knowledge of the characters of the strata in depth can be gained from surface geological surveys, should, if complete sets of samples were obatined, result in interesting additions to the knowledge of the geological conditions bearing on the possibility of encountering oil or gas.

[1]Information regarding boring records for Alberta, Saskatchewan, Manitoba, and North West Territories will be found in Part B of the Summary Report, and for eastern Canada in Part C.

[2]Geol. Surv., Canada, Sum. Rept. 1925, pt. A, pp. 145-146.

OTHER FIELD WORK

Geological

H. T. James. Mr. James made a detailed survey of the Britannia copper ore deposit and of the rock formations in a surrounding area of about 90 square miles, of which a contoured topographical map had been prepared some years previously. A report and map, intended to constitute his doctorate thesis, are now being prepared by Mr. James at Massachusetts Institute of Technology, Boston. Although these results are not yet complete they are expected to be an important contribution to existing knowledge of ore deposition, especially in the Cordilleran region, and great credit is due to the officials of the Britannia Mining Company for the generous manner in which access was given to the mine and to their records.

C. S. Evans. Mr. Evans surveyed the rock formations for a width of about 4 miles on either side of the Rocky Mountains trench (site of the Canadian Pacific railway between Golden and Cranbrook) northward from Windermere map-area, a map (No. 2070) and report (Memoir 148) upon which, by J. F. Walker, have recently been published. Although no important mineral occurrences are known in the areas examined a knowledge of the rock formations is of much importance for a proper understanding of the geology of southeastern British Columbia. The Rocky Mountains trench, also, is one of the most impressive physical features in British Columbia and its origin and relation to geological structure are of much scientific interest. A report and map are being prepared by Mr. Evans for submission to Princeton University as his doctorate thesis and for subsequent publication by the Geological Survey.

Topographical[1]

J. A. Macdonald. Mr. Macdonald made a phototopographical and plane-table survey of Bear River mineral area, on Portland canal. This area was mapped on a scale of 1 inch to ½ mile, with a contour interval of 250 feet, and will be published in the form of two half sheets, viz., west half of Stewart sheet, latitudes 55° 45′ to 56° 00′ and longitudes 129° 45′ to 130° 00′ and the west half of American Creek sheet, latitudes 56° to 56° 15′ and longitudes 129° 45′ to 130° 00′.

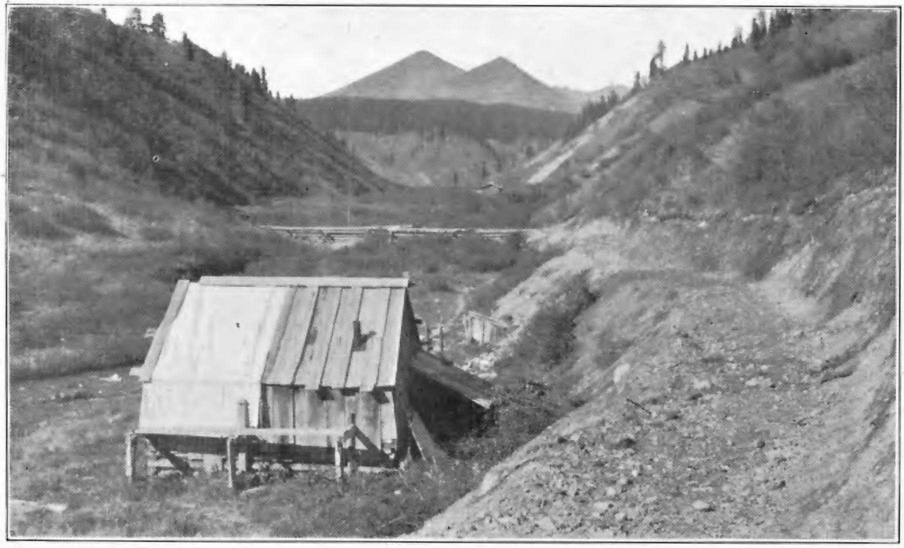
A. C. T. Sheppard. Mr. Sheppard, assisted by S. M. Steeves, surveyed the west half of the Cranbrook sheet; between latitudes 49° 30′ and 49° 45′, and longitudes 115° 45′ and 116° 00′. This area, which was mapped by phototopographical and plane-table methods, includes the town of Cranbrook and the Sullivan, North Star, and Stemwinder mines. The scale of work was 1 inch to ½ mile, with a contour interval of 100 feet.

[1] During the year a change was made in the system of naming Geological Survey one-mile map-sheets. Heretofore, a unit one-mile map-sheet embraced an even 15 minutes of latitude and longitude and had a distinctive name; under the present system a unit one-mile map-sheet embraces 15 minutes of latitude and 30 minutes of longitude. This unit sheet, or full sheet, is given a distinctive name and the two halves, 15 minutes of latitude and longitude, comprising the full sheet, are called the east half and west half respectively. This system conforms with the sheet outlines adopted by the Military Surveys, Department of National Defence, for their one-mile maps. In the above report the names of sheets refer to the full sheets 15′ and 30′ of latitude and longitude.

A. Placer mining on discovery claim in Goldpan creek, Cassiar district, B.C. (Page 52.)

B. View down Thibert creek, from above mouth of Berry creek, Cassiar district, B.C.; showing on the right, the old channel of the creek that has been partly hydraulicked out. (Page 61.)

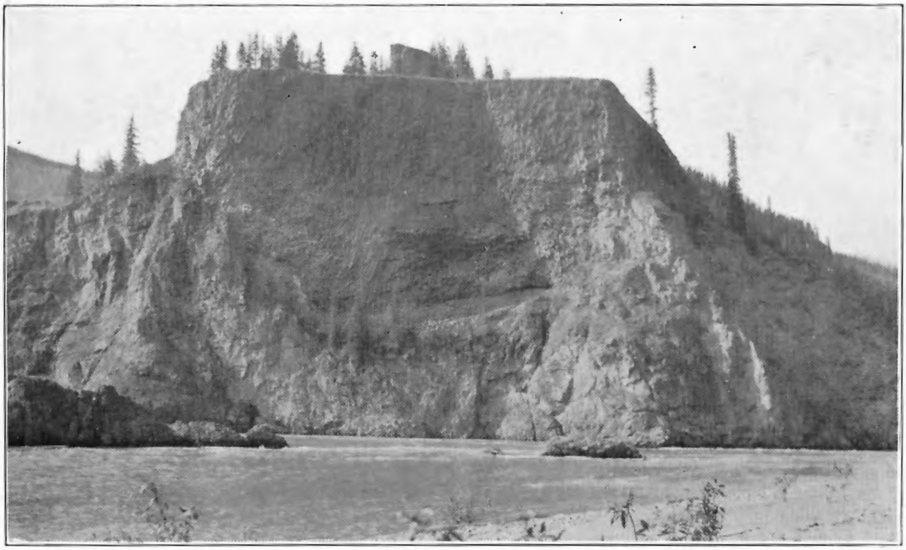
PLATE II



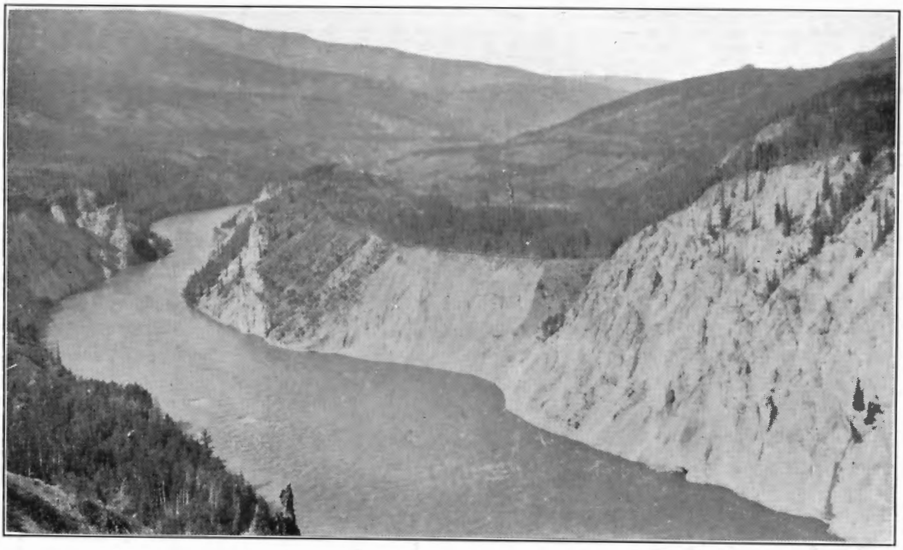
A. View of Mosquito creek; Defot mountain in the distance, Cassiar district, B.C. (Page 68.)

B. Lava flows underlain by gravels; west bank of Tahltan river at trail crossing, Cassiar district, B.C. (Page 70.)

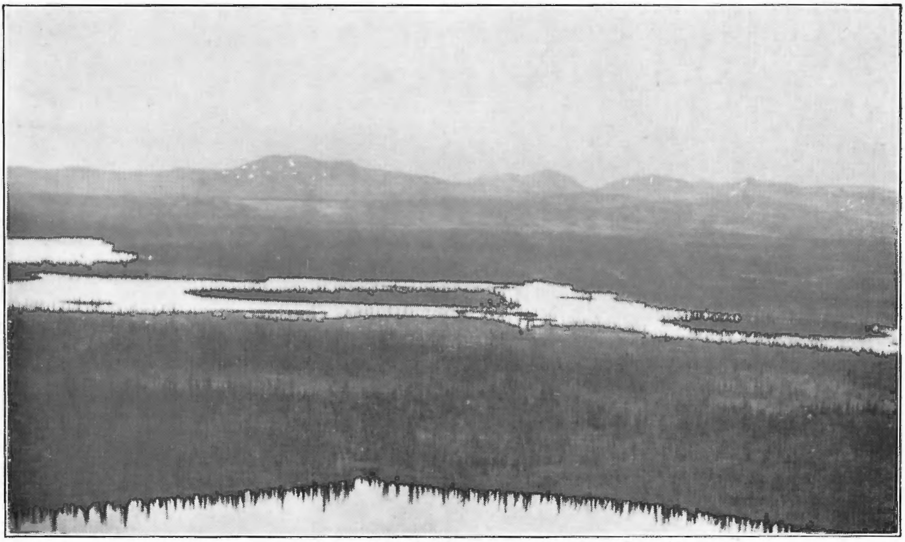
PLATE III



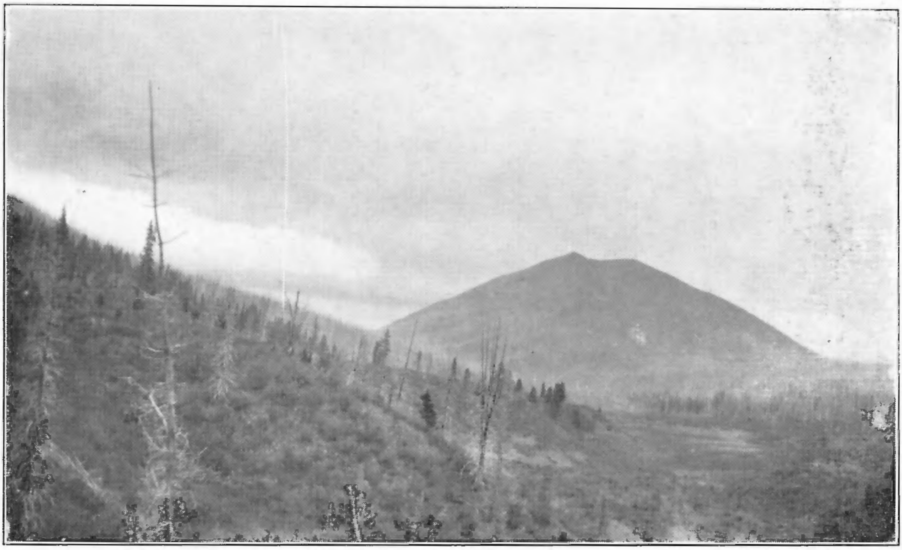
A. Lava flow overlying gravels in old river channel; south bank of Stikine river at mouth of Tahltan river, Cassiar district, B.C. (Page 70.)



B. View up the Great canyon of the Stikine, 3 miles above Telegraph Creek, Cassiar district, B.C.; showing, on the right, a drift-buried channel of the stream. (Page 70.)



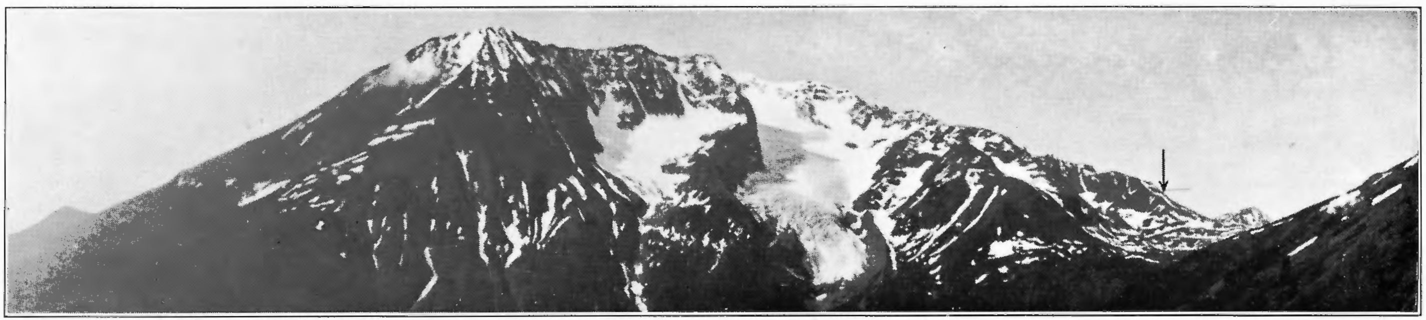
A. Plateau country west of Eagle river; Cassiar mountains in the distance, Cassiar district, B.C. (Page 78.)



B. Slough mountain, a volcanic cone, Cassiar district, B.C. (Page 95.)

PLATE V

A. Looking westward towards Hudson Bay mountain from Bulkley valley. (Photograph by A. C. Garde, Smithers, B.C.) (Page 121.)



B. Looking southwest from the northern segment of Hudson Bay mountain, Coast district, B.C. (from arrow point in A). Valley of Toboggan creek in the foregound. Arrow indicates location of Silver Creek mining property. Bulkley valley on extreme east of photograph. (Photograph by A. C. Garde, Smithers, B.C.) (Page 138.)

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