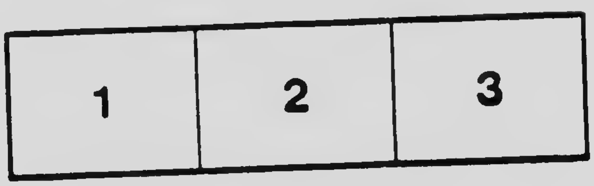
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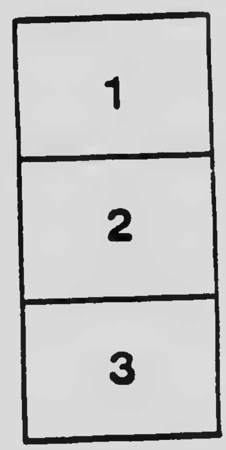
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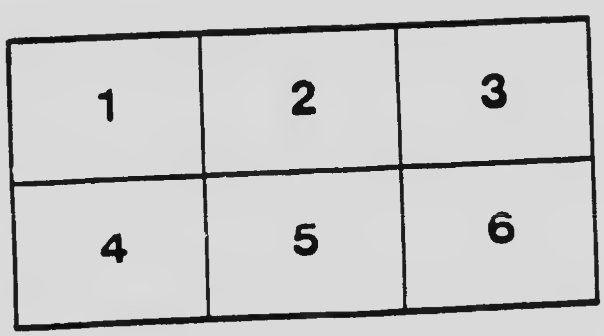
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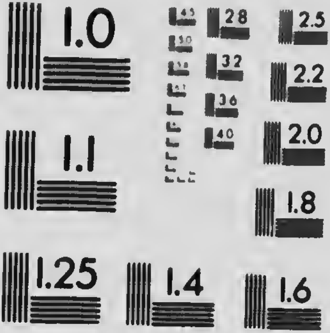

CANADA
DEPARTMENT OF MINES
GEOLOGICAL SURVEY BRANCH

Hon. Robert Rogers, Minister; A. P. Low, Deputy Minister;
R. W. Brock, Director.

MEMOIR No. 37

PORTIONS

OF

ATLIN DISTRICT

BRITISH COLUMBIA:

WITH SPECIAL REFERENCE TO LODE MINING

BY

D. D. CAIRNES.

OTTAWA
GOVERNMENT PRINTING BUREAU
1913

No. 1255

Frontispiece

Specimens of quartz showing free gold from the Engineer mines
Atlin Mining District British Columbia

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28627—A

No. 1255

LETTER OF TRANSMITTAL.

To R. W. Brock, Esq.,
Director Geological Survey,
Department of Mines.

Sir,—I beg to submit the following memoir on "Portions of Atlin mining district," together with topographical and geological maps.

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

(Signed) D. D. Cairnes.

Ottawa, June 9, 1911.

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ILLUSTRATIONS

Photographs.

Drawings.

NOTE.—The above-mentioned map is only preliminary. Detailed geological and topographical maps are in preparation and will be published later.

PORTIONS OF

ATLIN DISTRICT, BRITISH COLUMBIA:

WITH SPECIAL REFERENCE TO LODE MINING.

D. D. Cairnes.

INTRODUCTION.

GENERAL.

Atlin became known as a productive placer-gold camp early in the year 1898, and since then a number of creeks on the east side of Atlin lake, within a radius of 15 or 20 miles from the town of Atlin, have made this one of the more important gold-producing centres in Canada. A number of quartz claims, also, were located during the summer of 1899 and properties of this type have been developed more or less from time to time, and, although the attention and efforts of most persons interested in mining in this district have been mainly directed to the placer deposits, yet a few prospectors and mining-men have continued to prospect for, and develop the non-placer ore deposits, and have succeeded in maintaining a certain amount of interest and hope and even, at times, enthusiasm, concerning lode mining in this district.

Since about 1905 greater attention has been given to the lode-mining industry, partly on account of the promising character of some of the more recent discoveries on Taku arm and also because the Atlin placer deposits are known to be slowly becoming exhausted, and those interested in the welfare of the district are watching more keenly than formerly the development of lode-deposits with the hope that they may continue to foster the mining industry when the gravels no longer are profitably exploitable. In 1899 Prof. J. C. Gwillim reported on Atlin district for the Geological Survey of Canada, and a reconnaissance topographical and geological map accompanies his report. Since the year 1899 and 1900, when the field work for this report and map was performed, conditions pertaining to placer mining have not materially altered, the geology of the gravels too is fairly well understood, but development has been more rapid in the case of the other mineral deposits of the district. Accordingly the writer was instructed by the Director of the Geological Survey to make an examination of the more important mineral deposits other than those of placer gold, in Atlin district, and, in addition, to make a topographical and geological survey of a belt including Taku arm from the 60th parallel south past the head of this water, thus including the greater number of the more recently located quartz properties; the following report is the result of this work which was performed during the summer of 1910.

The writer desires to express his sincere thanks for the hearty support received by his party and himself from all those interested in mining in the district with whom they came in contact. Particularly is the writer indebted to Mr. J. A. Fraser, Gold Commissioner; Mr. J. Cartmel, Mining Recorder; and Captain James Alexander, Mr. B. G. Nicol, and Mr. J. Dunham, owners of the Engineer Mines, for assistance rendered and for courtesy extended during the summer.

In the performance of the work a small gasoline launch and two canoes were used for transportation on Taku arm and Atlin lake, and as these waters are subject to frequent and very sudden storms of considerable violence, the gasoline launch not only facilitated the work in that the party was able to travel faster with it than with canoes, but work was made possible on a considerable number of days when, owing to stormy weather, it would have been impossible with canoes. A suitable launch also obviated much of the danger attached to this work as such a boat is comparatively safe in any of the sudden storms that occur, some of which, in four or five minutes, become very dangerous for ordinary canoes. One of the canoes used was fitted with air-compartments along the sides and was found to be much better adapted to the work than ordinary canoes which are not safe and should not be employed in work of this description on these lakes.

The main camps of the party were all situated on the shores of Taku arm and Atlin lake and their tributaries, but a number of temporary camps were located inland, to and from which the necessary supplies and equipment were generally packed by the members of the party, but pack horses were used for moving up Bighorn creek.

A base about 1½ miles long was measured along the east shore of Taku arm just above Racine's old mill, and from there a triangulation was extended over the district surveyed. The topography was filled in largely by means of phototopographic methods, but all roads and trails were traversed with a 4-inch prismatic compass and odometer, numerous points along these traverses being tied to the triangulation by transit. The shores of Taku arm were traversed with transit and Rochon micrometer.

The geological portion of the work was performed with approximately the same degree of accuracy as the topographical, but since no topographical map was available in the field, considerable difficulty was experienced in taking notes, making sketches, etc., concerning geological boundaries, in such a manner that these could later be accurately shown upon a completed topographical map.

Mr. G. G. Gibbins, B.Sc., Mr. P. A. Fetterly, B.Sc., and Mr. John Lanning, assisted the writer during the entire field season and performed the greater part of the topographical work. Mr. Gibbins also assisted in geology when circumstances permitted. All discharged their duties in a satisfactory and able manner.

LOCATION AND AREA

Atlin mining district is situated in the northwestern corner of British Columbia between north latitudes 59° and 60° (the British Columbia-Yukon boundary), and extends from longitude 132° to 134° 30′ west of Greenwich (Diag. 1). All the more important lode and coal properties in the district were examined by the writer during the summer of 1910, and, in addition, a geological and topographical survey was made of the western portion of the tract, or as it is here designated, Taku Arm belt, which embraces a northerly trending area 45 miles long and about 16 miles wide. This belt includes all the British Columbia portion of Taku arm which also trends northward, occupying a median position in the area surveyed. The mapping covers, as far as possible, the localities containing

Diag. 1. Sketch map showing the geographical situation of Atlin mining district.

promising mineral discoveries, including a number that are shown on Prof. Gwillim's map of Atlin mining district.

ACCESSIBILITY AND TRANSPORTATION

A rail and steamboat service connects Atlin with the Pacific coast at Skagway. Commodious steamers make regular trips throughout the year between Seattle and Skagway, Alaska, and also between Vancouver and Skagway, distances of 1,000 and 867 miles respectively. From Skagway the White Pass and Yukon railway has been constructed to Whitehorse, Yukon, a distance of 111 miles. From Caribou[1] a point on the railway 67 miles from Skagway, a steamer makes two trips a week to Taku Landing, which is about 70 miles from Caribou and is situated at the eastern end of Graham inlet, an arm of Taku arm. A railway 2 miles long extends from Taku Landing (Plate I) to a point on the western shore of Atlin lake, whence a steamer connects with the town of Atlin on the eastern shore about 3 miles distant. All points on Atlin lake and Taku arm are thus directly connected by rail and steamboat service with Skagway.

Wagon-roads have been constructed from Atlin up Pine and Spruce creeks and their more important tributaries, also up Fourth-of-July creek. Roads or trails have been made up Pike river, McKee creek, and other important streams on the east side of Atlin lake. A wagon-road has also been built from Kirtland on the west side of Taku arm to the lode-discoveries on Bighorn creek, and roads have been constructed connecting the workings at the Engineer mines and Gleaner group with the east shore of Taku arm.

During the winter season a stage runs regularly between Carcross and Atlin—a great part of the journey being made on the ice; in the late and early winter, just before navigation is open and after it closes, while the ice is uncertain, dog-teams carry the mail between these points.

HISTORY.

General.

Atlin became known as a productive placer camp within a few months of the date of the discoveries made by Miller and McLaren on Pine creek in January of the year 1898. These men made the

[1] Originally known as Caribou Crossing, but now called Carcross by the Post Office authorities and Caribou by the railway people.

trip into the district from Skagway over the White pass, and travelled thence by way of Bennett lake and river along Taku arm and its tributary, Torres inlet, to Atlin lake and the creeks flowing in on the east, and since these prospectors made the journey with dog sleds during the most severe part of the winter, a time altogether unsuitable for prospecting, it would appear very probable that gold was previously known to occur in the district, and this supposition is supported by the statements of miners and prospectors along the Alaskan coast. There is, however, no evidence to show that, as is commonly supposed, gold was previously mined from the gravels of the Atlin creeks; a small amount of prospecting may have been done, but nothing more.

The gold production in 1898 was about $75,000, but in the following year it amounted to $900,000. From 1900 to 1907, inclusive, there was a somewhat uniform production, the average for these years being about $411,000. The production in the year 1908 was $263,000, and in 1909 it was $260,000.[1]

Several different routes were followed by travellers to and from Atlin camp in its early days, among which the most important are the Fantail route, the Taku route, and Telegraph-Teslin trail route. The Fantail route was a short trail for dog sleds from Skagway over the White pass, whence, following in a northeasterly direction, it continued down a long, wide depression to Fantail lake and thence across Taku arm to Atlin lake. The Taku route led from Juneau up Taku river and Nakina river to the mouth of Silver Salmon river, thence up Silver Salmon valley and over a low divide at Pike lake to Atlin lake. The Telegraph-Teslin trail route was all overland and followed the Telegraph-Teslin trail from Glenora to Teslin lake, thence across the ranges westward to Atlin lake.

Bibliography

The bulk of the literature concerning Atlin district is to be found in the reports of the Minister of Mines of British Columbia. Each of these, from the 1898 volume to the volume last issued, contains the report of the Gold Commissioner at Atlin for the year,

[1] These figures are taken from the reports of the Minister of Mines of British Columbia.

Plate I

[illegible]

and three contain reports by the Provincial Mineralogist, in addition, in the 1899 volume short reports appear by Prof. J. C. Gwillim and Mr. R. C. Lowry. Prof. Gwillim was also employed by the Geological Survey of Canada in this district during the summers of 1899 and 1900 and his "Report on the Atlin Mining District," which is accompanied by a topographical and geological map, includes all the information available concerning the district up to that time. The following is a list of publications concerning Atlin district in addition to the yearly reports of the Atlin Gold Commissioner.

Robertson, W. F. (Provincial Mineralogist), Reports of the Minister of Mines, B.C., 1898, pp. 985-990; 1900, pp. 753-770; 1901, pp. 56-83.

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Young, Rosalind W., "Mining in Atlin, British Columbia," Jour. Can. Min. Inst., 1909, pp. 177-191.

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"Portions of Atlin district, B.C.," Sum. Rep. Geol. Survey, Dept. of Mines, 1910, pp. 27-59.

SUMMARY AND CONCLUSIONS.

TOPOGRAPHY.

Taku Arm belt is a northerly trending area about 45 miles long by 16 miles wide, in which Taku arm occupies a median position, and acts as the main drainage channel of the district. All the streams of the area empty into this arm and their water flows thence through Tagish and Marsh lakes, and Lewes and Yukon rivers to the Arctic ocean.

The belt lies, for the greater part, in the Yukon Plateau province, but to the south it includes a portion of the eastern edge of the Coast range. Thus two contrasting types of topography occur in the district. The Yukon plateau is an extensively dissected and eroded plateau, in parts of which almost no trace of the original upland remains, and the topography consists of irregularly distributed rounded hills whose summits may or may not rise to a somewhat uniform elevation; in other localities, however, numerous flat-topped interstream areas of uniform height remain. The valleys are everywhere wide, deep, steep-walled, typically U-shaped depressions.

The Coast range is extremely rugged, consisting mainly of knife-like ridges, needle-summits, and abruptly incised valleys, and everywhere considerable ice and snow are to be seen throughout the entire year.

These two physiographic provinces are believed to have been planated to a mature stage and the Plateau region and possibly the Coast range as well, are considered to have been peneplanated. Subsequently these terranes were uplifted, apparently 3,000 to 4,000 feet, the movement being greatest along the axis of the Coast range, and least along the central portions of the Yukon Plateau region. The streams were thus rejuvenated, and soon entrenched deep V-shaped valleys in the uplifted surface. Glacial ice then invaded the district and occupied all the main depressions which were both widened and deepened and given U-shaped cross-sections, and such well known forms as cirques, hanging-valleys, roches moutonnées, pot-holed valley floors, etc., were produced. Morainal and other glacial materials were deposited in the valley bottoms, and have produced reversed slopes in most of the main valleys causing the waters to be dammed above, in the form of lakes. Tagish lake, including Taku arm, and Racine, Tutshi, Fantail, Edgar, and Nelson lakes have all been caused in this way and represent the positions occupied by the last tongues of the retreating ice, which melted so rapidly toward the last, that the depressions they occupied had not time to become filled with detrital material.

The wide difference between the topography of the Coast range and that of the Yukon plateau seems to be due mainly to three causes. In the first place, the Coast range is composed largely of massive granitic rocks which do not possess bedding planes, nor alternating hard and soft layers to be emphasized by erosion, so that subaerial agencies have had no regular control and have thus produced very erratic forms. The irregular jointing plains in these rocks have also in places assisted in the production of bold, irregular topographic forms. Secondly, these granitic rocks are generally harder and in most places erode less rapidly than the rocks of the plateau and, therefore, have caused the Coast range in this district to retain a greater general elevation than the region to the east. Thirdly, since, for various reasons involving differential erosion and uplift, the Coast range is now higher than the Plateau region, it still contains glacial ice although the glaciers have long ago vanished from the plateau region. The glacial ice continues to accentuate the features of the Coast range, whereas in the plateau province, since its retreat, nivation has been active in the uplands smoothing over inequalities. Thus once a line of demarcation was established between these two terranes, their features have steadily become more and more contrasted.

GENERAL GEOLOGY.

The extreme northern and southeastern portions of Taku Arm belt are included in the Coast range and consist of Coast Range granitic rocks which are mainly greyish, coarsely textured granodiorites. The remainder of the area extends well out in the Yukon Plateau region and contains a considerable variety of geological formations which range in age from lower Palæozoic or older to Recent, and include igneous and sedimentary members as well as certain metamorphic rocks of obscure origin.

The oldest rocks consist of a group of pre-Devonian schistose and gneissoid members as well as some limestone bands. These have been invaded by and, in places, extensively buried under a wide-spread group of Devonian (?) andesites, andesitic tuffs, diabase, diorite, and magnesite. During Devono-Carboniferous time several thousand feet of sediments accumulated, which are now limestones, slates, and possibly cherts. The cherts are of somewhat obscure origin, and occur in only a few small areas, but are everywhere associated with the slates. The limestones are very extensive and have an aggregate thickness of at least 5,000 feet.

Overlying the limestones, the more recent of the Devono-Carboniferous rocks, are Jura-Cretaceous conglomerates, sandstones, shales, greywackes, tuffs, slates, and quartzites, having a thickness in places, of over 5,000 feet.

The Coast Range granitic intrusives that compose the Coast range and also form dykes, stocks, etc., in the Yukon Plateau region, are in most places, greyish, coarsely textured, granodiorites, and are generally described as having been intruded in Jurassic time. The evidence obtained in Taku Arm belt, however, shows that they were intruded during different, and widely separated periods, some before and some after the deposition of the Jura-Cretaceous sediments.

The Jura-Cretaceous sediments and the Coast Range granitic intrusives, as well as the various rocks of the district older than these, have been pierced by various volcanics and in places have been covered by a considerable thickness of lavas and associated tufaceous accumulations. These volcanics range in age from late Cretaceous or early Tertiary to Pleistocene and include andesites, andesitic tuffs, granite-porphyry, basalts, basalt tuffs, rhyolites, and rhyolitic tuffs. Overlying all the consolidated geological terranes of the district are Pleistocene and Recent accumulations, consisting chiefly of gravels, sands, clays, silts, muck, peat, and soil, which deeply floor the main valley bottoms and also extend well up the side hills and in places even occur abundantly on the uplands and mountain summits.

ECONOMIC GEOLOGY

The section of this memoir dealing with economic geology has reference to the entire Atlin mining district, and thus differs from the other parts of the memoir, which refer only to the western portion of the area, or as it is here designated, Taku Arm belt.

The various deposits of economically important minerals (other than placer gold, with which this memoir is not concerned) that occur in Atlin mining district have been tentatively classified as follows:

I. ORE DEPOSITS.

(*a*) Gold-tellurium quartz veins.
(*b*) Gold-silver quartz veins.
(*c*) Cupriferous silver-gold veins.
(*d*) Silver-lead veins.
(*e*) Copper veins.
(*f*) Antimony veins.
(*g*) Contact metamorphic deposits.

II.—COAL.

Gold-tellurium veins have been found in only one locality which is situated on the west side of Taku arm above Golden Gate, at the Engineer mines and adjoining claims, and much the richest ores discovered in Atlin mining district have been obtained from these properties. The discovery at the Engineer mines of a number of pockets of quartz worth from \$3 to \$5 per pound, caused much excitement during the summer of 1910, and had a decided effect in arousing enthusiasm in lode-mining. The most wide-spread group of deposits are the gold-silver veins which are found in a number of localities scattered over the greater part of the district. Cupriferous silver-gold veins have been found only on Table mountain, and only one vein worth noting has been discovered. A number of strong, well-mineralized veins belonging to the silver-lead division occur on Crater creek and in that vicinity. Copper veins have been found only on the southern end of Copper island, and those so far discovered do not appear to be of any present economic value. One antimony vein is known to occur in the district; it outcrops on the west shore of Taku arm 10 miles below Golden Gate, but as the deposit has been exposed for only about 15 feet very little is known concerning it. Contact metamorphic deposits, so far as is known, occur only on Hoboe creek near the upper end of Torres channel, and since they follow a single contact, it may be better to consider them as a single deposit, as there is nothing to indicate that the ore does not follow the contact continuously between the points where its outcrops have been encountered. The ore body, which consists largely of magnetite carrying varying amounts of copper, exceeds 30 feet in thickness everywhere it has been exposed, and is at one point 150 feet in thickness. Outcrops have been discovered throughout a distance of 3,000 feet or more along the contact.

No coal seams in place have been found, but Tantalus conglomerate, which is always associated with coals in southern Yukon, occurs at several points, and a considerable amount of float coal has been found to the northeast of the lower end of Sloko lake where the seams from which this is derived should easily be found.

A considerable number of the mineral deposits occur along the shores of Taku arm and have thus direct boat connexion with the railway at Carcross. Most of the other occurrences are on, or within short distances of navigable waters, and are not far from the railway. In connexion with the utilization of these ores an order of the railway commission in 1910, that the freight rates charged by the White Pass and Yukon railway on ores, shall not exceed $1.75 per ton from Caribou (Carcross) to Skagway, is of importance since the ores and concentrates can be sent by boat directly from Skagway to the various coast smelters.

In conclusion, it may be said, that Atlin mining district possesses quite a variety of economically valuable minerals which occur in places in deposits of considerable size, and that in some of the mineral veins, pockets of exceptionally rich gold ore have been found; also that practically all the deposits are readily accessible. The lode-mining industry in the district has made a good beginning and will probably continue to develop in the future. The results up to the present are particularly encouraging when it is remembered that since 1898, when mining commenced in the district, nearly all persons engaged in this industry have devoted practically all their attention to the gold-bearing gravels, and that, until very recently, there has been a relatively slight amount of prospecting for quartz.

GENERAL CHARACTER OF THE DISTRICT.

TOPOGRAPHY.

General Account.

REGIONAL.

The greater part of northern British Columbia and Yukon Territory may be broadly divided into three physiographic provinces which persist southeasterly through British Columbia, and to the westward through Alaska. Named in order from southwest to northeast, these provinces are: the Coastal system, the Interior system, and the Rocky Mountain system. These terranes constitute the Cordillera of northwestern North America, and follow in a general way the peculiar concave contour of the Pacific coast line. They thus all trend northwesterly through British Columbia, strike in a westerly direction through Alaska, and in Yukon, in between, they follow an intermediate course. Lying to the north, northeast, and east of the Rocky Mountain system are plains or lowland tracts—the Arctic Slope region, the Mackenzie lowlands, and the Great Plains (Diag. 2.).

The Yukon Plateau province constitutes the entire Interior system in Yukon and in northern British Columbia southeastward to about latitude 58°, whence for about four degrees of latitude the region is mountainous and consists, according to Dawson,[1] of disturbed Cretaceous rocks. Beyond this mountainous portion of the Interior system the surface gradually declines to the upland of the Interior plateau, which continues southeasterly to a point a few miles south of the 49th parallel.[2]

From about the 50th to near the 60th parallel, the coastal system embraces only the Coast range, if the islands to the west be considered to form part of a separate range,[3] but the simplicity of this

[1] Dawson, G. M., "Geological record of the Rocky Mountain region in Canada"; Geol. Soc. of Amer., Vol. 12, p. 61.

[2] Daly, R. A., "The nomenclature of the North American cordillera between the 47th and 53rd parallels of latitude," Geog. Jour., June, 1906, p. 588.

[3] Dawson has separated the Vancouver range from the Coast range. See Dawson, G. M., Trans. Royal Soc. of Can., 1890, Vol. 8, Sec. 4, p. 4. Geol. Soc. of Amer., Vol. 12, pp. 61, 62.

western province is interrupted near the head of Lynn canal, whence northward and northwestward, the coastal system consists of two or three ranges, in some cases separated by wide valleys as well as by

DIAG. 2.—THE PHYSIOGRAPHIC PROVINCES OF YUKON AND NORTHERN BRITISH COLUMBIA.

Note.—The position of Taku Arm belt is shown by small rectangle.

subordinate mountain masses. The Coast range after following the coast line from southern British Columbia to near the head of Lynn canal, passes behind St. Elias range, and for the remainder of its course northward, constitutes the most easterly portion of the coastal system. North of Lynn canal, the range gradually becomes less prominent, until it merges into the Yukon plateau, near Lake Kluane, at latitude 61° and longitude 138° 30'.

The Coast range consists, in a general way, of an irregular complex of peaks and ridges, that possess but little symmetry other than a rough alignment parallel to a northwesterly-trending axis. The range has everywhere a precipitous and jagged aspect, and consists largely of knife-edged crests, rugged or even needle-like summits, and sharply incised valleys. The summits in southern British Columbia rise to uniform altitudes of from 8,000 to 9,000 feet above sea-level, but to the north they gradually decrease in elevation, and in Yukon stand at only 5,000 to 6,000 feet above the sea. This change in altitude, though great, is so gradual that it does not break the apparent uniformity of summit level which, however, bears no relation to structural features. This terrane has thus been considered by a number of geologists[1] who have studied it topographically, to represent a peneplanated, or at least a mature to old surface of erosion, subsequently elevated (Plate II).

The Yukon Plateau province stretches from the inland ranges of the Coastal system to the base of the Rocky mountains, and, near the 60th parallel of latitude (the Yukon-British Columbia boundary), is 250 to 300 miles wide. In northern British Columbia some well defined ranges lie within this region,[2] and in Yukon and Alaska many single peaks and minor ranges[3] rise above the plateau level.

[1] Dawson, G. M., "Report on the area of the Kamloops map sheet, B.C.," Ann. Rep., Geol. Surv. of Can., Vol. VII, 1894, p. 10B.
Hayes, C. W., "An expedition through Yukon district," Nat. Geog. Mag., Vol. 4, p. 128.
Spencer, A. C., Bull. Geol. Soc. of Amer., Vol. 14, p. 132.
Brooks, A. H., "Geography and Geology of Alaska," Prof. Paper, No. 45, pp. 286-290,291, U.S. Geol. Survey.

[2] Dawson, G. M., "On the later physiographical geology of the Rocky Mountain region in Canada," Trans. Royal Soc. of Can., Vol. 8, Sec. 4, 1890, pp. 4, 5.

[3] Fortymile atlas sheet, U.S. Geol. Survey.
Spurr, J. E., "Reconnaissance in southwestern Alaska," 20th Ann. Rep., Geol. Survey, pt. VII, 1898-99, pp. 238-242.

Into this upland surface in southern Yukon and northern British Columbia the main drainage courses have incised channels varying from [illegible] to 4,000 feet in depth, thus producing a very irregular topography. The summits of the unreduced hills and ridges, lying between the waterways, mark a gently rolling plain which slopes toward the north and northwest. The plateau, seen from a summit that stands at about the level of the upland, will impress the observer with its even skyline, sweeping off to the horizon, and broken only here and there by isolated, residuary masses that rise above the general level. This plane, however, bears no relation to rock structures, erosion having levelled the upturned edges of the hard as well as the soft strata; in fact, its surface is entirely discordant to the highly contorted, metamorphic rocks that make up much of the plateau, and, as is more fully discussed later, is evidently an uplifted and dissected peneplain, produced by long-continued subaerial erosion during a period of crustal stability (Plate III).

Along the northern portion of the Coast range, the general summit level merges into that of the Yukon plateau, in a manner suggesting the synchronous planation[1] of these two provinces, a view that is held by Brooks, Spencer, and others; but during the various vertical movements that have affected these terranes, the uplift has been greatest along the axis of the Coast range and least along that of the Yukon Plateau province, which terrane is thus given the contour of a huge flaring trough whose median line is, in a general way, marked by the present position of Yukon river from near its headwaters in northern British Columbia to Bering sea.

The Taku Arm belt, which was surveyed during 1910, is for the greater part situated in the western part of the Yukon Plateau region, but also extends a short distance into the Coast range. There, no distinct line of demarcation indicates the boundary between the plateau and mountain provinces; these, instead, grade into each other, so that a transition belt occurs, generally from 1 to 4 miles wide, in which many of the points cannot definitely be said to belong to either terrane.

[1] Spencer, A. C., Bull. Geol. Soc. of Amer., Vol. 14, p. 132.
Brooks, A. H., "Geography and geology of Alaska," Prof. Paper, No. 45, pp. 286-290, 293, U.S. Geol. Survey.

Plate II.

The Coast range in the distance, showing the striking and characteristically uniform summit level.

Looking eastward across [illegible] showing [illegible] of the Yukon Plateau region

LOCAL.

The portion of Atlin district surveyed during the summer of 1910, as previously mentioned, is a northerly trending belt that extends about equal distances on both sides of Taku arm from the 60th parallel south to past the upper end of this water, and includes the upper portion of Atlin lake. Since the main physiographic terranes of northern British Columbia trend northwesterly, and Taku arm runs almost due north, the southern portion of the area mapped includes part of the Coast range, while the northern limit reaches well into the Yukon Plateau region (Diag. 2). The transition from the plateau to the mountain portions of Atlin district is very gradual, so much so, that it is, in places, difficult to determine where one ends and the other begins.

The plateau topography is characterized by two striking features, the numerous, irregularly-distributed, wide, deep, steep-walled valleys, and the elevated and in places slightly undulating, inter-valley upland areas. The upland-surfaces in spite of dissection and erosion are in many places extensively preserved, and there, as elsewhere in the Yukon plateau, bear no relation to rock structures, but, instead, the sandstones, shales, granites, schists, limestones, volcanics, etc., have been truncated, regardless of their respective degrees of hardness, structural features, etc. (Fig. 1).

Standing on one of these upland tracts, well back from the edges of any valley-wall, and so situated that his field of vision includes the uplands and not the deeply trenched valleys, an observer sees these areas as portions of one plain, and it is easy to picture it a continuous undissected surface, as it once probably was. The topography, as seen from such a viewpoint, has but slight relief, and obviously was produced by a long-continued period of erosion, at the end of which a mature to old stage in the physiographic cycle was reached. Nearer the edges of the present depressions, topographic unconformities are everywhere in evidence at the intersection of the abrupt valley-walls with the plateau-surface. Near the lower end of Taku arm the upland is approximately 3,300 feet above the lake level, or 5,460 feet above the sea, and towards the southern end of the arm the plateau-surface is somewhat higher.

Occasional hills rise above the general level, and represent the

Fig. 1. Geological section south of Golden Gate, showing the plateau surface truncating the different rock formations and cut by the valley of Taku arm

only considerable masses that the ancient erosive agencies left standing above the old plain-like surface, erosion having been interrupted before the work of destruction was completed. Mt Clive and Sunday peak are notable examples of such mountain-remnants.

Over considerable portions of the district, the plateau surface has been almost if not quite destroyed by later erosion, and in such places the topography consists of irregularly-distributed, rounded hills, many of them gently-contoured and with summits that are in many cases remarkably uniform in elevation (Plate IV).

The principal valley in the district is that occupied by Taku arm, the upper 15 miles of which lie in British Columbia. The arm is in most places from 1½ to 2 miles wide, but the entire valley-bottom has, in places, a width of as much as 4 miles. At its upper or southern end, the arm turns abruptly to the west, the southward continuation of the main depression being occupied by Hale creek and Edgar and Nelson lakes.

Numerous cross-valleys join the main Taku Arm valley, in the larger of which lakes and their outlet streams, or arms and inlets of Taku arm occur, the more important of which are Graham inlet, Talaha bay, Tutshi lake and river, Racine lake and river (Plate V), and Fantail lake and river. All these valleys are U-shaped, deep, wide, and steep-walled. The streams joining these larger drainage-channels almost invariably have hanging valleys, and the smaller the stream the higher its valley is hanging above that of the larger depressions.

Towards the south and west the surface of the Yukon plateau gradually rises and becomes more and more dissected, and the topography consequently assumes an increasingly rugged aspect until the Coast range is reached, which is characterized by knife-edged crests, needle-summits, and sharply-incised valleys. In the precipitous valley-walls numerous ice-masses nestle and the ice increases in amount southwestward until, a few miles above Atlin lake and Taku arm, the great Llewellyn glacier is encountered, which overrides all except the loftier peaks and spurs.

Sometime subsequent to the deposition of the Jura-Cretaceous beds—the most recent of the consolidated sediments in the district—the tract now included in the Yukon Plateau region of southern

Yukon and northern British Columbia, was apparently subjected, as already indicated, to a long period of subaerial erosion which continued until a plane-like surface resulted, having an elevation slightly above that of the sea, and with only occasional residuary peaks and ridges rising above the general level; from the attainment of these results it may be inferred that the land during this time remained in a state of almost perfect stability. This erosion-cycle was terminated by a gradual uplift of the Yukon Plateau region together with adjoining portions, at least, of the Coast range. Erosive processes thus received new life and energy, causing the streams to rapidly entrench their channels in the elevated terrane. The effects of stream action, in this respect, were later accentuated by glaciation. The main ice-masses occupied the master-depressions such as that of Taku arm, and both straightened and planed their slopes, and widened and lowered their floors. The valleys thus produced were wide, deep, and steep-sided. The ice also acted in a constructional capacity and caused the valleys, in places, to become floored to considerable depths with glacial silts, sands, gravels, boulder-clays, etc. The formation of such lakes as Taku arm and Tutshi lake, which now occupy the portions of the valley-bottoms that were last occupied by these glaciers, is owing to the fact that the ice retreated up the valleys so rapidly that only the lower portions were filled with glacial debris, causing reversed slopes and effectually impounding the water above.

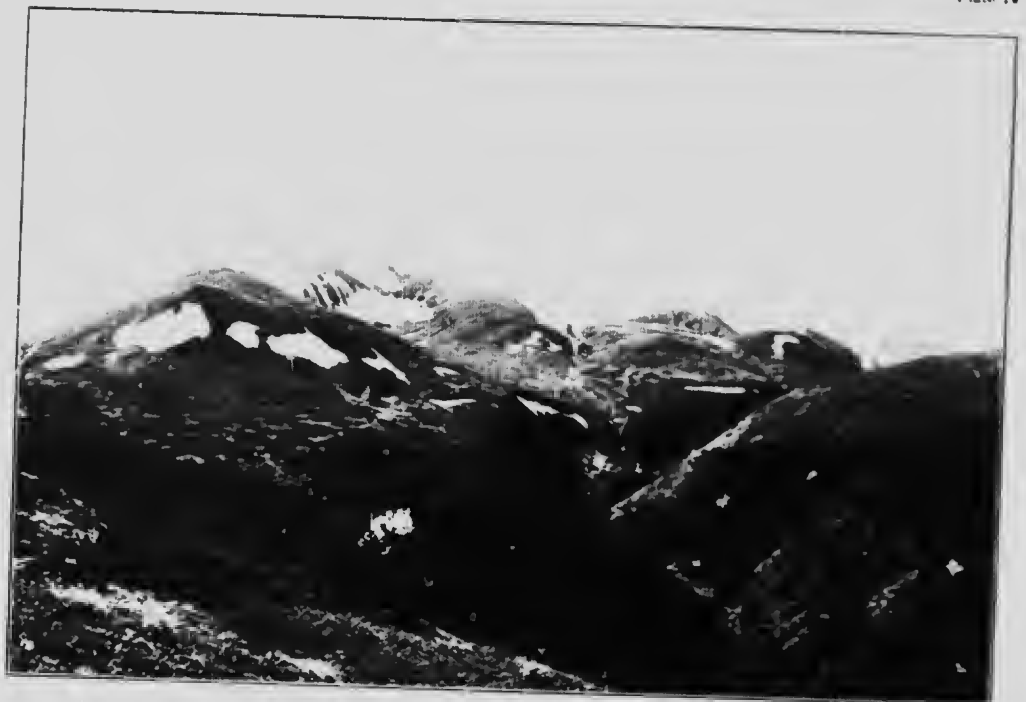
In the present plateau-region the only representatives of the former glaciers are the few small ice-masses that still occupy occasional cirques; so that in the uplands nivation[1] or snow-drift action has been at work and has tended to smooth over inequalities in the land surface rather than accentuate them. In the Coast Range region, however, on account of its higher altitudes, the ice is still abundantly present and cirques on opposite sides of the ridges and around the summits are being excavated downward and back-

[1] Nivation in its different phases, relations, results, etc., is discussed in the two following articles:—

Matthes, F. E., "Glacial sculpture of the Bighorn Mts.," Wyo., U.S. Geol. Surv., 21st Ann. Rep., Pt. II, 1900, pp. 173-190.

Hobbs, W. H., "Cycle of mountain glaciation," Geog. Jour., Feb., 1910, pp. 147-163.

Plate IV



A typical rounded summit south of Graham inlet. Such mountains are characteristic of considerable portions of the Yukon Plateau region

Plate V.

Looking across Taku arm and up Racine valley, toward the Coast range

ward toward one another. Some have nearly met, and rugged knife-like ridges or arrêtes, as well as pinnacle-like summits are the result.

Detailed Topography.

[illegible]

The Uplands.—Over portions of Taku Arm belt lying within the Yukon Plateau region, the plateau characteristics are still well preserved, and numerous fragments of almost flat, or gently rolling upland still remain in spite of sub-aerial erosive agencies which tend to destroy the old surface. Hale and Lanning mountains afford excellent examples of these plateau fragments, and on their surfaces it is possible to walk several miles over but slightly undulating upland about 3,000 to 3,500 feet above the level of Taku arm (Plate VI). Over considerable portions of the district, however, little trace of the former upland remains and the topography consists of isolated, generally rounded hills, many of the summits of which rise to about the elevation of the plateau surface. In places erosion has succeeded in removing the plateau surface entirely, and only low, irregular hills remain which show no concordance of summit level (Plate VII). In the Coast range, plateau fragments, if they exist, are of rare occurrence, and none were noted in Taku Arm belt.

The plateau surface to be observed to the best advantage must be viewed from interstream points, situated some distance back from the edges of the master valleys; from such positions the even, gently rolling character of the plateau is strikingly apparent. The surface bears no relation to rock structure, and the pre-Devonian, contorted schists and gneisses, the Jura-Cretaceous tuffs, greywackes, sandstones, shales, and conglomerates, and the various volcanics, are all truncated, regardless of their structure, hardness, composition or other qualities. A few, generally rounded, summits such as those of Mt. Clive, and Sunday peak, are the only conspicuous elevations rising above the general level.

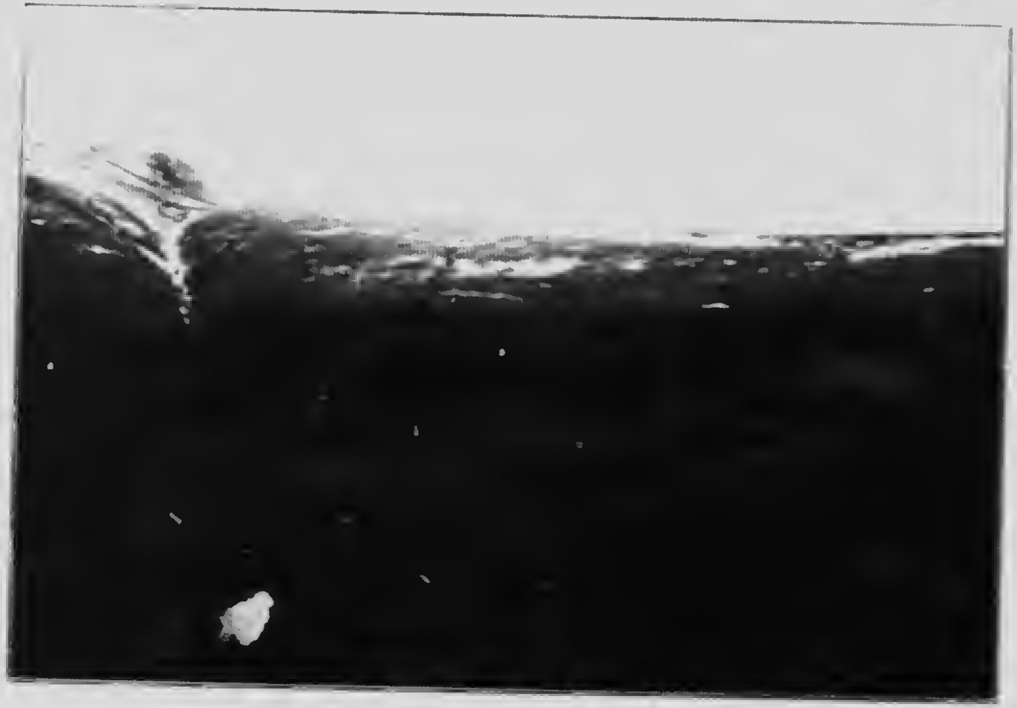
The plateau surface thus represents a plain of erosion that has probably been produced mainly by ordinary erosive agencies rather than by glaciation, since if it has been produced by glaciation its surface would be everywhere strewn with foreign glacial materials, which is, generally, not the case. In places there is evidence such as the occurrence of striae and erratics, that ice has moved over the plateau surface, but the greater part of the upland is covered with local material produced by ordinary erosive and weathering agencies.

This plateau surface thus appears to form part of a region that during a long period of crustal stability was almost completely base levelled, and was reduced to a condition of old age. At the time of planation the Taku Arm upland must thus have formed a portion of a plain the edge of which was at or nearly at sea-level. The residual mountains that now constitute monadnocks rising above the plateau level, represent the only considerable elevations that remained to break the monotony of the former landscape. Base-levelling processes, which tended to reduce the entire plateau region to sea-level, were interrupted, before the reduction of these remaining hills, by an uplift which affected a great portion, at least, of British Columbia and Yukon.

The time during which this planation occurred, as well as the date of the subsequent uplift, are somewhat in doubt. The evidence obtainable in Taku Arm belt shows only that some time after the intrusion of the Coast Range batholith, which is thought to have occurred in Jurassic times, and also after the Jura-Cretaceous Laberge beds were deposited and somewhat deformed, this portion of the Yukon plateau, as well possibly as the adjoining portions of the Coast range, were reduced to a condition of but slight relief and that subsequently, but in pre-glacial time this district was uplifted to about its present position in pre-glacial time. Investigations by different geologists in various portions of the Yukon plateau and neighbouring terranes indicate, however, as described under "General Geology," that this planation occurred during Eocene, or pre-Pliocene post-Eocene time, and that the planated tract was subsequently uplifted during the late Miocene, Pliocene, or early Pleistocene epoch.

The amount of uplift is also somewhat indefinite. Taku arm is about 2,160 feet above sea-level, and Lewes and Yukon rivers, which carry this water to the sea, have grades much in excess of rivers traversing a district in its old age. Further, it seems very improbable that the area, prior to uplift, was drained by a longer water system than the present circuitous one; in fact, investigations

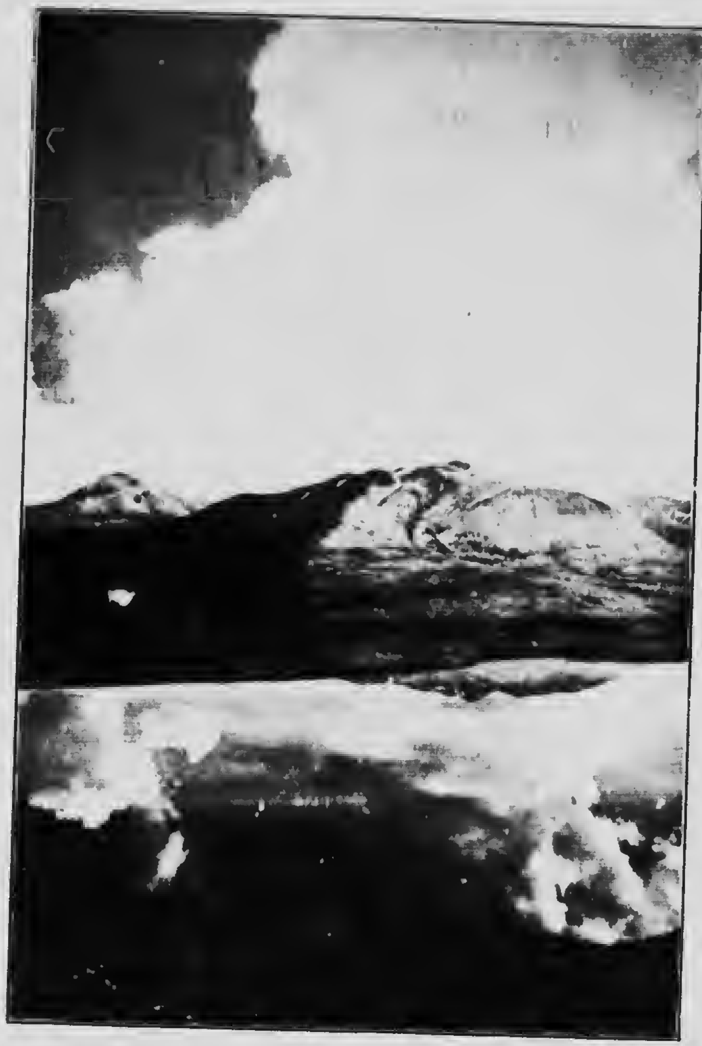
Plate VI.



Near view of a typical portion of glaciated upland

Plate XIII.

[illegible]

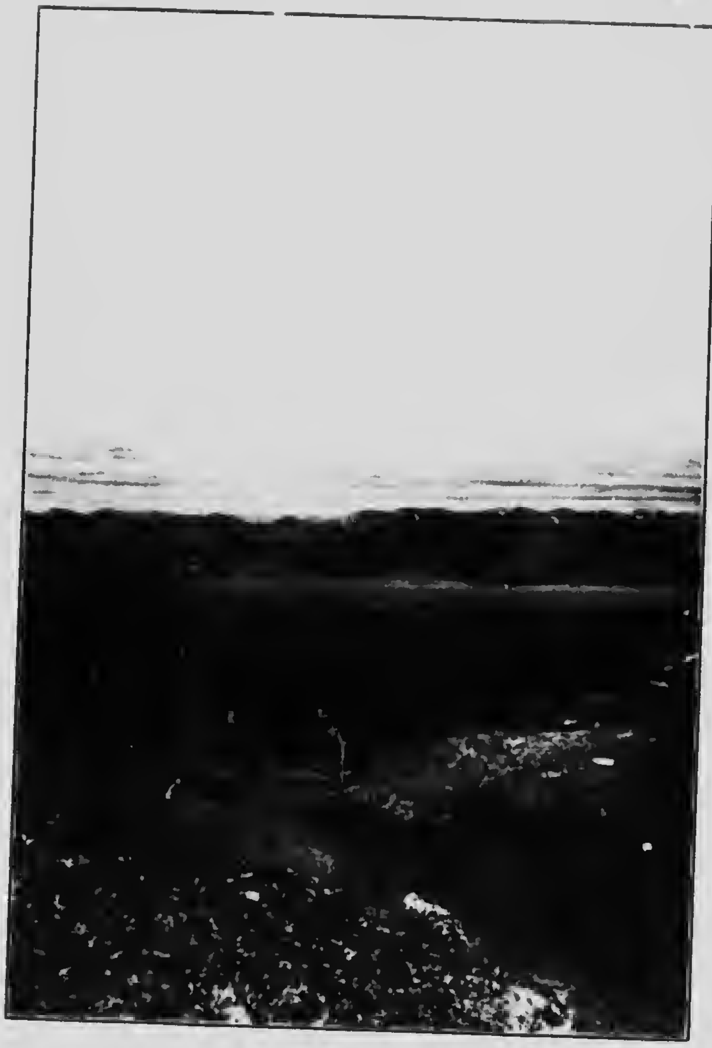


Looking easterly across Taku arm toward Sunday peak, which is prominently shown in the centre of the view. This is one of the typical, rounded, isolated mountains that characterize portions of the Yukon Plateau region.

Plate IX.

Near view of a dissected portion of upland, showing the sharp V shaped, non-glaciated incisions in its surface, and the hanging valleys of the small streams draining it.

Plate X.



Looking eastward across Atlin lake, showing a typical view of the district to the east.
23627—p. 22.

have tended to show that the district was drained into the Pacific by a much shorter system.[1] The general surface of Taku Arm belt was thus probably less than 2,160 feet above sea-level, when the uplift commenced, while now the upland has an average elevation of about 5,700 feet. The vertical extent of the movement was, therefore, greater than the difference between 5,700 and 2,160 or 3,540 feet; and probably was 4,700 to 5,200 feet.

When the Yukon Plateau region of northern British Columbia and southern Yukon was uplifted at the beginning of the present erosive cycle, it assumed the form of a broad, shallow trough the sides of which sloped downward toward a median line. The results of this differential lift are well illustrated in the Taku Arm belt where the upland surface inclines upward toward the southwest and gradually rises until the level of the Coast Range summits is reached (Plate XI).

The majority of Canadian and United States geologists, including Brooks, Spencer, and Dawson, who have studied the Coast range, consider that it also represents a peneplanated and subsequently uplifted surface, and Brooks, Spencer, and others are convinced that the Coast range and Yukon plateau were synchronously planated and uplifted. McConnell on the other hand maintains that the Coast range, where examined by him, shows no evidence of ever having been peneplanated.

In Taku Arm belt, the striking uniformity in elevation of the mountains of the Coast range suggests that this terrane may be an uplifted and dissected plain of erosion. Moreover, the upland surface of the Yukon plateau merges with the summits of the Coast range in a manner suggesting the synchronous planation and subsequent uplift of the two provinces (Plate XII). When the Yukon Plateau region was uplifted, the adjoining Coast range must also have been forced upward unless faulting occurred between the two terranes and there is no evidence of this; nowhere, for instance, are valleys known to exist along the junction between the mountain and plateau regions, which might indicate faulting. It thus seems practically certain t t these provinces suffered erosion during the same

[1] Brooks, A. H., "Geography and geology of Alaska," Prof. Paper, No. 45, U.S. Geol. Surv., 1906, p. 294.
Dawson, G. M., Trans. Roy. Soc. of Can., Vol. VIII, Sec. 4, 1890, pp. 15-24.

period and were afterward uplifted together. There is some doubt, however, as to the extent to which the Coast range was planated, as the original surface as it existed before the uplift has been almost, if not quite, destroyed (Plate XIII).

It is possible that the area now occupied by the Coast range existed as a range of residual hills when the plateau region to the east was a peneplain, but the bulk of the field evidence indicates, in the writer's opinion, that both provinces were at least maturely eroded, that the Yukon plateau even attained a condition of old age, that the entire mountain-plateau region was synchronously uplifted, and that the axis of the Coast range which has been a locus of previous disturbances, was uplifted higher than the adjoining belt to the east. That the uplift of the Coast range was very gradual is shown by the fact that the several rivers which flowed into the Pacific across that part of the region, maintained their courses.

Sometime subsequent to the uplift of the mature terraces, and the development of the present valley systems, a climatic change caused glaciers to form in the higher regions, and great tongues of ice moved from these gathering grounds down the main valleys of Taku Arm belt. The Coast range became extensively glaciated, but the upland of the Yukon plateau was only slightly affected, though the presence of occasional erratics and small patches of foreign materials shows that at least occasionally, bodies of ice passed over portions of the plateau surface.

During Pleistocene and Recent times, the plateau surface, although only slightly modified by moving ice, has been considerably affected by accumulations of snow. At no time, apparently, did snow gather on the surface in sufficient quantities to form any considerable masses of ice, but for the most part, it seems to have been blown by the winds into the valleys and depressions.

The effects of névé snow are to convert shallow V-shaped valleys into flat U-shaped depressions, to efface their drainage lines without materially changing their grades and in this manner, to produce general smoothness of surface. Since the snow-drifts have no sliding motion, there is no transportation of material by them; however, because of excessive frost action, and continued alternations of freezing and thawing, the rocks, at the peripheries of the quiescent snow, are finely comminuted and the material is removed by

Plate XI

Looking southwesterly from the summit of Hale mountain. The view shows the even plateau surface sloping gradually upward to join that of the rugged Coast range.

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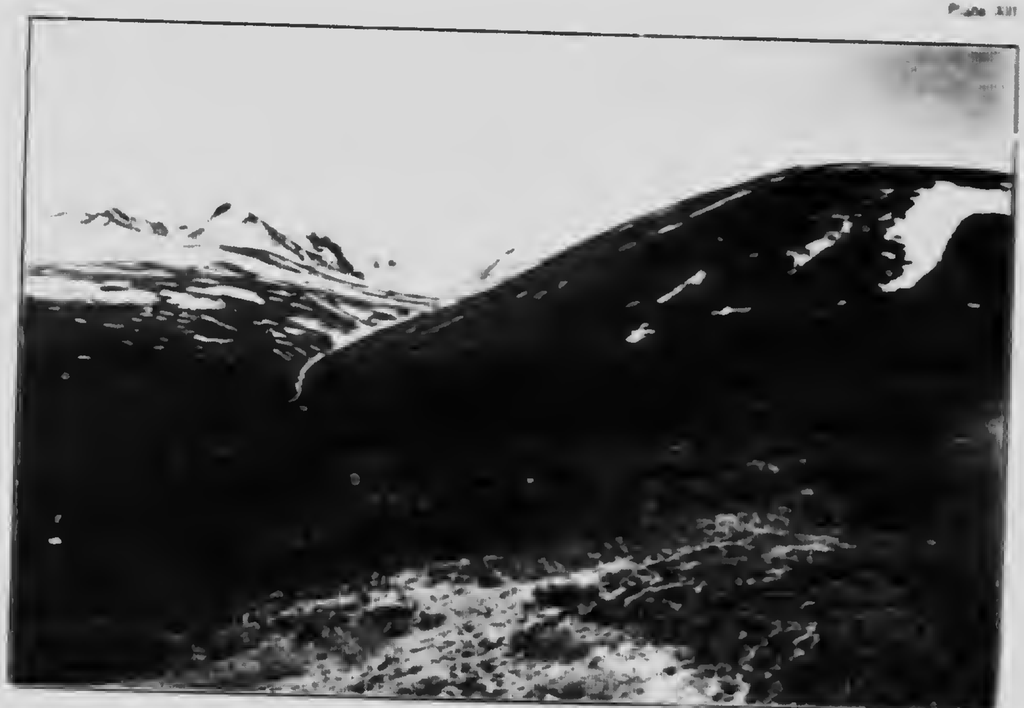
Plate XIII



Looking westerly toward Mt. Clive. A gradation is shown between plateau and mountain [illegible]. [illegible] being difficult to say just where the Coast range really commences.

Plate [illegible]

View of a portion of the Coast range just west of [illegible] mountain.

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innumerable rills to neighbouring depressions. These effects of the work of quiescent névé, called nivation[1], have resulted in grading, to a considerable extent, the already gently rolling surface of the plateau region, and account to a considerable extent for the great amount of fine material that fills all the minor depressions in the upland surface. The presence of the snow also helped to preserve the smooth outlines of the topography, by protecting the surfaces from stream action.

Thus the following causes appear to mainly account for the contrasting topographies of the Coast range and Yukon plateau. In the first place, the Coast range was uplifted more than the plateau tract and was consequently subjected to a greater degree to erosive agencies; and as the mountains of the Coast range are composed mainly of homogeneous grano-diorite the forms produced by erosion are noticeably extremely irregular since no bedding planes or lines of hard and soft layers exist to be emphasized by degradation. Secondly, the rocks of the Coast range are generally harder and more resistant to ordinary sub-aerial agencies than are the rocks to the east, and the more nearly the rocks of the plateau approach those of the mountains in physical properties the less apparent, and more gradual is the change from plateau to mountain provinces. Thirdly, the Coast range is sufficiently high to still hold great amounts of glacial ice which is actively employed accentuating the features of the mountains and giving them a typical fretted appearance. In the case of the Yukon plateau, on the other hand, the ice, except for small masses in occasional cirques, has long since vanished from the region, and instead of the features there continuing to become more pronounced, they are being rounded and smoothed over by nivation. Thus once a difference of elevation between these two provinces was established, their features became continually more and more contrasted. This appears to account mainly for the striking difference in the physiography of the two terranes, although apparently synchronously planated and uplifted.

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[1] Nivation in its different phases, relations, results, etc., is discussed in the two following articles:—

Matthes, F. E., "Glacial sculpture of the Bighorn Mountains, Wyo.," U.S. Geol. Surv., 21st Ann. Rep., Pt. II, 1899, pp. 173-190.

Hobbs, W. M., "Cycle of mountain glaciation," Geog. Jour., Feb., 1910, pp. 147-163.

The Valleys.—The main valleys in Taku Arm belt are characteristically wide, steep-sided, flat-floored, U-shaped depressions with decided topographic unconformities everywhere in evidence at the contact of the upper edge of their walls with the upland surface (Plates V and X). The master valley of the district is that occupied by Taku arm, which is about 59 miles long (Plate XV). The lower (northern) 54 miles of this water has an almost due northerly trend, but above there the arm turns abruptly to the west at right angles to its previous course. The upper 45 miles of the arm lie within British Columbia and occupy a median position in Taku Arm belt. The water itself is in most places from 1½ to 2 miles wide, but the entire valley bottom has in places a width of as much as 4 miles.

The depression occupied by Edgar and Nelson lakes and Hale creek is really the southward extension of Taku Arm valley, but has been so filled with glacial debris at the point where it joins the southeast corner of the arm that this water has been excluded.

A number of important tributary valleys having easterly or westerly trends, join the valley of Taku arm. The more important of these are occupied by Tutshi lake and river, Racine lake and creek (Plate V), Fantail lake and river, Talaha bay, Graham inlet, and the extreme upper end of Taku arm and the glacial creek emptying into it. These are all steep-walled, U-shaped depressions and much resemble Taku Arm valley, differing from it mainly only in being narrower. Those of the tributary depressions that contain lakes drained by streams into Taku arm have had large amounts of glacial materials deposited in them, which have dammed back the waters above, forming lakes. In addition to these larger valleys, a number of smaller streams, occupying less prominent depressions, have hanging-valleys.

The U-shaped steep-walled character of all the main valleys, and the reversed slopes of many, causing lakes to form in them, are due, mainly at least, to glacial action. The upwarp of the district, previously discussed, gave the streams renewed life and energy, and they immediately began vigorously sinking their channels in the uplifted surface. Throughout the area deep V-shaped incisions were rapidly made, and these, in Pleistocene time, were invaded by

Plate XIV.

Looking easterly across Taku arm, Graham inlet, and Atlin lake. The wide U shaped valleys are here well illustrated.

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Plate XV.

Looking up Taku arm from near the Yukon and British Columbia boundary, showing the wide flaring character of Taku Arm valley

glaciers from the mountains to the south, southwest, and west, which have profoundly effected the topography of the district.

When a broad ice-sheet covers a district, it moderates the topographic features and reduces the relief, by eroding material from the higher elevations and depositing it in the depressions, but where the ice occupies only the valleys, as was the case over the greater part of Taku Arm belt, much greater results are seen and of a different kind; the interstream areas maintain their even character unaffected by ice, while the valleys are widened and deepened, the maximum effect being produced in areas which have been previously prepared to receive the ice by having deep valleys already made in which the ice can operate. Taku Arm belt is believed to have been so prepared, and in it V-shaped valleys have been transformed into wide, deep, U-shaped depressions, and hanging valleys, cirques, roches moutonnées, and other well-known glacial forms have been produced.

The main valley glacier in the district moved northward through Taku Arm valley and was joined by smaller bodies from the tributary valleys from the south and west. A considerable tongue of ice moved easterly down the valley occupied by the extreme upper end of Taku arm, and a similar body moved in a parallel direction down the valley of Fantail lake and river, and was in turn joined by ice moving northward down the valley of Bighorn creek. Other valley glaciers moved westward down the valleys of Racine lake and creek, and Tutshi lake and creek. The main ice mass in Taku Arm valley divided at Golden Gate (Plate XVI), and a portion moved eastward along the valley of Graham inlet and joined the greater glacier in the valley of Atlin lake. The ice thus all had a general trend northward as the water has to-day, but, similarly, many tributary ice-streams moved in various directions to join the master-valleys.

In addition to being mainly destructive, the glaciers also acted in a constructive capacity, and contributed vast amounts of morainal and other materials which in places deeply covered the floors of the master-depressions (Plate XVII). The waters of Taku arm and Tagish lake are impounded by glacial materials deposited in the valley of Tagish lake, and all the small lakes in the district occupy reversed slopes produced partly, at least, by glacial debris deposited in the lower portions of their valleys. It may, however, be possible that the ice ploughed deeper into the underlying bed-rock along certain portions of some channels than along others and so caused reversed slopes, but no proof of this has been obtained and the Pleistocene deposits are always in evidence at the foot of each lake. The positions now occupied by these bodies of water apparently represent those of the last tongues of the retreating ice which finally melted so rapidly that the depressions did not have time to become filled with glacial products.

Hanging Relations of Tributary Valleys.—The small streams that traverse portions of the plateau surface flow over the upland in wide, flaring, depressions, with comparatively gentle gradients, but at the edge of the elevated platform, they plunge suddenly, by successive falls, through gorge-like incisions, to join the master streams below. In other words, the tributaries have hanging valleys, and the smaller the stream the more its valley is hanging above the master depression.

Many of the smaller streams have only well nicked the walls of the master valleys, and several on Lanning mountain, Stovel mountain (Plate IX), Hale mountain, and other places, fall precipitously more than 2,000 feet to join the larger streams below. One particularly striking example of such a valley occurs on the west face of the hill just south of Golden Gate and facing Hale mountain (Plate XXV). The larger valleys such as that of Lanning creek, have been occupied by considerably larger ice and water streams, and the hanging relationship is less pronounced. Bighorn creek is one of the largest creeks in the district (Plate XXX) and at its junction with Fantail river, almost no hanging relationship is noticeable. All gradations between these different conditions are to be found.

Various explanations have been advanced to account for streams having hanging valleys, and although a number of causes such as certain structural features, meander cut-off, etc., may account for this phenomenon in individual localities or cases, still when it is general throughout a district the hanging relationship has been discovered to be always in some way due to glaciation. In this connexion, it has been suggested that since tributary valleys are more or less confined and higher than the larger depressions, the ice

Plate XVI.

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Looking southwesterly toward Golden Gate (indicated by the arrow). The view also shows the wide flaring U shaped character of the main valleys, and the topographic unconformities everywhere encountered at the upper edge of the valley walls.

Plate XVII.

Looking across Taku Arm valley, showing the extremely and minutely rough character of the valley floor, which is characterized by pot holes and irregularly distributed morainal ridges and mounds. The pot holes and depressions between accumulations of morainal materials are frequently occupied by small lakes or ponds.

would remain longer in them, and protect them from water erosion and weathering agencies, while the parent stream lowered its channel. Possible as this explanation may seem, if it is to account for the hanging valleys these should be more pronounced and plentiful on slopes facing the north than on those facing the south. This does not appear to hold true in Taku Arm belt although it is claimed to do so in certain other localities.[1]

In this district the hanging relationship appears to be due mainly, at least, to the glaciers in the master valleys having eroded and steepened their contain[illegible] walls to the extent that the lower portions of the tributary d[illegible] were entirely planed away. Since the disappearance of the ice, the tributary streams, on coming to the edges of the parent valleys, fall precipitously over their abrupt glacially-steepened walls to join the lakes or larger streams below. The larger the [illegible] in a tributary valley, the more nearly will ice and water [illegible] kept pace with that in the parent depression, and consequent[illegible] less the smaller valley is left hanging; and where two [illegible] there is no hanging relationship resulting from [illegible]

Cirques.—Cirques are among the most prominent and characteristic features of the Coast Range part of the district, but only a few were noted in the Yukon Plateau portion, and most of these occur around the summits of high individual mountains. On Lanning and Fetterly mountains and elsewhere, well preserved cirques were noted, but these generally contain little or no glacial ice; [illegible] each as a rule holds a small lake which is generally in the pro[illegible] being reclaimed, by ordinary erosive agencies (Plate [illegible]. Nearer the Coast range, however, the cirques contain more i[illegible] cirque on Gleaner mountain is partly filled with it during [illegible] entire year.

As the Coast Range mountains are approached, cirques become more numerous and glacial ice more and more plentiful, until the great Llewellyn glacier is encountered, which overrides all but the loftier peaks and spurs. The cirques occur around the rugged summits and along the sides of the various ridges, and excavation con-

[1] Garwood, E. J., "Features of alpine scenery due to glacial protection," Geog. Jour., Sept., 1910, p. 317.

tinues backward and downward until the cirque-walls from opposite sides of ridges and crests meet. Knife-like arrêts and needle summits are thus produced, and the topography assumes the typically frayed or fretted aspect so characteristic of the Coast range (Plate XIX).

Facetted Forms.—The great masses of ice in the master depressions planated the valley slopes, reducing all projecting spurs, ridges, etc., and bringing them into alignment to form in many cases quite regular walls. Since the close of the glacial epoch, the numerous small tributary streams from the upland have been cutting channels in these walls and have been enlarging the pre-glacial incisions in them. The result is that numerous V-shaped trenches are cut in the steeply-inclined valley slopes, and between them are left facetted forms, carved on the valley walls (Plate XX).

These features are quite pronounced along the head of Taku arm (Plate XXI) and are of common occurrence in the upper portions of the various transverse valleys leading from the west toward Taku arm.[1]

Terraces.—Terraces are of somewhat rare occurrence in Taku Arm belt, but a number were noted on the west side of Taku arm in the vicinity of the mouth of Tutshi river. They range in elevation from 10 to 250 feet above the arm and are composed dominantly of fine well-rounded materials. Similar terraces are of common occurrence in most of the main valleys throughout the Yukon Plateau physiographic province, and have been described by a number of writers.[2]

The origin of these terraces is somewhat in doubt. Dawson and Spurr considered that subsequent to the uplift of the Yukon plateau, and after the valleys had become deeply trenched, a submergence occurred in late Pliocene or Pleistocene time. The valleys are thus thought to have become partly filled with gravels, sands, silts, etc.

[1] Dawson, G. M., Trans. Roy. Soc., Can., Vol. VIII, Sec. 4, 1890, pp. 36-41, 48, 49.
McConnell, R. G., Ann. Rep. Geol. Surv., Can., Vol. IV, 1888-89, pp. 47D-28D.

[2] Russell, T. C., Bull. Geol. Soc. of Amer., Vol. I, p. 139.
Spurr, J. E., "Geology of the Yukon Gold district": Eighteenth Ann. Rep., U.S. Geol. Surv., Pt. III, 1896-97, pp. 268, 269.
Nordenskiold, Otto, The Amer. Geol., Vol. XXIII, pp. 291-292.
Brooks, A. H., Prof. Paper, No. 45, U.S. Geol. Surv., 1906, p. 296.

Plate XVIII.

Typical cirque on Fetterly mountains, in the Yukon Plateau region. The ice which produced the cirque has long since disappeared, and erosive agencies are now actively filling and reclaiming the depression.

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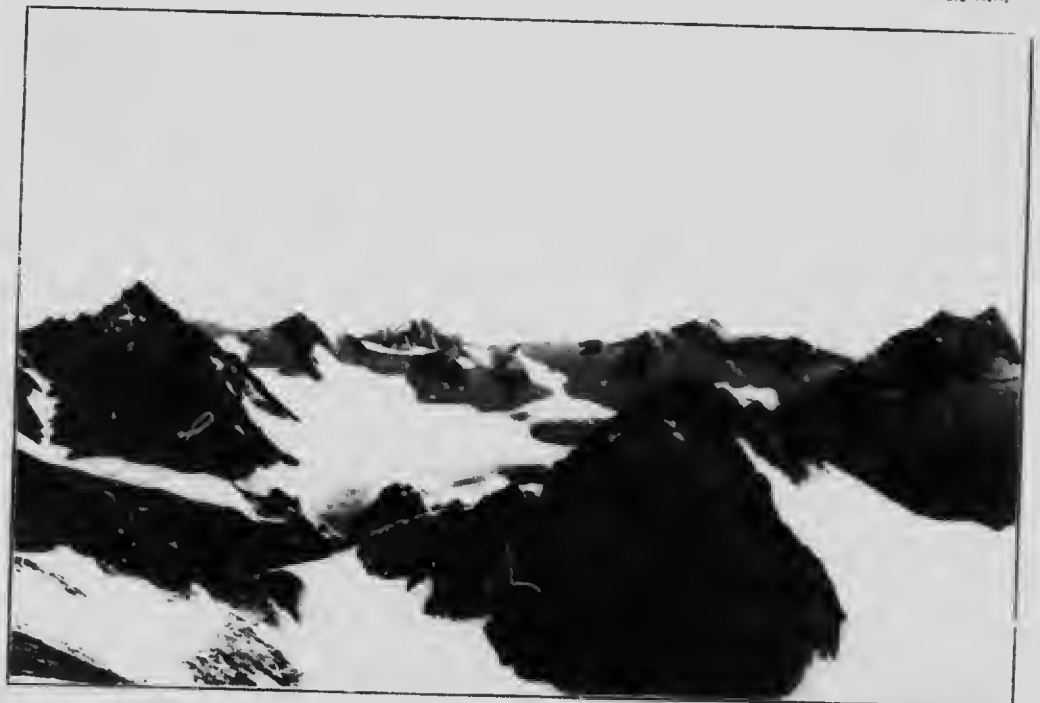
Plate XIX.



Near view of the Coast range from just south of the upper end of Taku arm showing the rugged character of the topography.

Looking across the upper end of Taku arm. The view shows the steep character of the valley walls with their pronounced facets due to glacial truncation of marginal spurs.

Plate XXI.

Looking northwesterly across the extreme head of Taku arm. The view shows the precipitous character of the granitic valley walls, and the glacial flats above the arm.

After a brief period, elevation commenced, and as the streams cut down through the debris, terraces were left clinging to the valley walls, the amounts of the subsidence and uplift being indicated by the terraces.

The postulation of a submergence and subsequent uplift appears to the writer to be quite uncalled for to explain the origin of these terraces. It is true that a certain amount of uplift has occurred in recent times and may be still in progress as indicated by certain rock terraces along Yukon river above Dawson and elsewhere, but these appear to have had an origin quite distinct from the gravel, sand, and silt terraces which characterize many of the valleys of northern British Columbia and Yukon. In whatever manner the terraces were formed, they must have originated since the glacial period, otherwise the valley glaciers would have entirely obliterated them. It is further evident that no great amounts of material have been deposited in the valleys since glacial time, as in many depressions, such as along the White Pass and Yukon railway between Carcross and Whitehorse, around Annie lake[1], and in places along Taku arm (Plate XVII), the valley floor is pot-holed and minutely rough, and possesses still the characteristic appearance of a surface that has recently been overlain by ice.

Brooks and others have supposed the terraces to be due to changes in the erosive powers of the streams, and in places this appears to be true, but in Atlin district and other portions of Yukon territory where the terraces reach high up on the valley walls, this theory calls for the former existence of vast amounts of material over the present valley floors, which, as shown above, cannot be the case, in some localities, at least.

It has been also supposed that the terraces are really remnants of lateral moraines formed along the edges of the valley glaciers and that they consist thus partly of ground-up debris accumulated by the ice itself, and partly of materials that rolled down the sidehills from above, and gathered along the upper surface of the ice. As the ice retreated and stood at successively lower elevations, other accumulations would tend to form, and those left above would remain

[1] Cairnes, D.D., "Wheaton district," Geol. Surv. Branch, Dept. of Mines, Can. (Mem. No. 31, 1912).

in the form of terraces clinging to the valley walls. The most persistent and prominent of the terraces would thus mark elevations at which the ice maintained constant elevations for exceptionally long periods.

In certain valleys where the terraces have been poorly preserved it is difficult to *disprove* this theory. However, at points in Wheaton district and elsewhere quite extensive flat-topped terrace accumulations remain in the mouths of the tributaries, and extend out flush with the edges of the walls of the master valleys. If the terraces originated due to ice action, the ice would also have invaded the mouths of the tributaries and the entire lower portions of such would not now contain flat topped accumulations.[1]

It thus seems evident, as suggested by Nordenskjold and others, that these terraces are predominantly, at least, lake terraces and represent successive elevations at which the water stood in post-glacial time. This calls for a damming of the drainage system somewhere along the lower Yukon river. As the terraces indicate that the period of submergence was brief, the damming was probably due to accumulations of ice or other glacial materials.

DRAINAGE.

All the waters of Taku Arm belt drain into Taku arm and are thence conveyed through Tagish lake, Marsh lake, Lewes river, and Yukon river, to the Arctic ocean. Taku arm occupies a median position in the district, is in most places from 1½ to 2 miles wide, and has a length of about 50 miles of which the upper 15 miles lie in British Columbia. With the exception of the upper [illegible] miles which trends easterly, the arm has an almost due northerly course.

Graham inlet, which is 16 miles long and about a mile wide, joins Taku arm from the east, at Golden Gate. The waters of Atlin lake drain through Atlin river and Graham inlet into Taku arm.

The principal bodies of water in the district are Edgar, Nelson, Fantail, Racine, and Tutshi lakes, which are drained into Taku arm by rapid streams flowing through channels cut entirely in glacial and post-glacial debris. The more important streams are those draining these lakes of which Fantail river is the largest. In addition, Big

[1] Cairnes, D. D., Op. cit. See section on terraces.

horn creek, a tributary of Fantail river, is a [illegible] stream. A large, glacial creek, also, empties into the extreme upper end of Taku arm and flows through wide flats formed of silt, which are still being rapidly produced by the glaciers above and along the sides of the valley (Plate XXI). The other streams of the district are of minor importance. All the streams are subject to rapid floods, as is evidenced by the presence of wide gravel and sand flats and bars in the more important drainage valleys.

CLIMATE

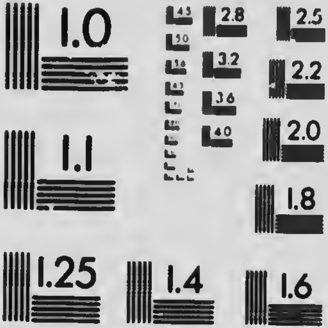
The climate of Atlin district and adjoining portions of northern British Columbia and southern Yukon has been, and by many still is, thought to be much more severe than it really is. It is true that during the early rush into Atlin in 1898 and 1899 great hardships were endured in some cases, and lives even were lost, but when it is remembered that the majority of the gold seekers were accustomed neither to a mountainous region nor to encounter the ordinary difficulties of travel in northern latitudes; that many of the prospectors set out on their quest with only the vaguest notion of the route to be traversed, that the route chosen was often one of the worst possible under the circumstances, and that a large proportion of the travelers made the trip during unfavourable seasons, it is perhaps surprising that so few casualties occurred, rather than so many.

Since the White Pass and Yukon railway was constructed over White Pass summit, and steamers were placed on the navigable waters, erroneous impressions concerning the climate of Atlin have been largely corrected and the district is becoming generally better known.

The summer months are particularly delightful, as, on account of the somewhat northern latitude, there is almost continuous daylight during June and July, and for four months warm summer weather is generally experienced. The amount of rain varies considerably in different localities, according to their elevations and the proximity of mountain ranges. The town of Atlin is situated well out in the Yukon Plateau belt and its climate

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



is inclined to be dry, although scarcely sufficiently so to be termed semi-arid.

Vegetation in the lowlands is luxuriant and its growth extremely rapid. The growing season seems short in number of days, but this is counterbalanced by the length of time the sun remains above the horizon, and the consequent increase in the number of hours of insolation. Wild fruits of several kinds occur plentifully and grow to large size. Agriculture has nowhere been seriously attempted, but gardens containing most of the common varieties of vegetables were seen in several places and all were doing very well and compared favourably with those seen in southern British Columbia.

The rivers and creeks generally open early in May, but on some of the lakes, ice remains until the first week in June. Slack water stretches freeze over any time after the middle of October, but some years the rivers and lakes remain open until December.

Surface placer-mining operations may generally be commenced early in May and continued until about the first of November, and all outside and surface work in connexion with mining and similar industries may be conducted for six months in the year; and on account of the long days, work may be performed during a considerable portion of the summer by night as well as by day, without the aid of artificial light.

FAUNA AND FLORA.

The valleys are generally well forested, but trees of any considerable size are not commonly found more than 500 feet above the valley bottoms; however, in some places the forests extend to 1,500 feet, and quite large trees were found in some sheltered spots, as much as 2,000 feet above this level (Plates XXII, XXIII). The main varieties of trees that occur are white spruce (*Picea alba*), black spruce (*Picea nigra*), balsam fir (*Abies subalpina*), black pine (*Pinus Murrayana*), aspen poplar (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), willows (*Salix*), dwarf birch (*Betula glandulosa*), and a species of alder. Of these the white and black spruce, which occur in about equal numbers, are the most abundant and valuable, and furnish strong, easily worked, timber well suited for the usual mining needs and for purposes of construction gener-

Plate XXII.

Showing a typical, wide somewhat heavily timbered depression. The timber is also seen reaching in places well up on the valley slopes.

28627—p. 34.

Plate XXIII.

Looking across the valley of Fantail river and along the eastern face of Hale mountain. This is one of the most thickly timbered portions of the Taku Arm belt.

ely. They thrive best in the valley bottoms where straight and well grown specimens 2 feet to 3 feet in diameter 3 feet from the ground are not uncommon, and most of the larger trees have 12 to 18 inch stumps. The black pine is not nearly so plentiful or valuable as the spruce and rarely exceeds 12 inches in diameter 3 feet from the ground; it is occasionally found interspersed with the spruce or forming separate groves, but generally grows on sandy benches along the main streams. The balsam fir, which supplies a fair grade of timber, thrives best on the slopes near timber line where many trees were observed having 12 to 18 inch stumps. In places on the flats bordering Taku arm, the best of the timber has been cut, to be sawed into lumber.

Aspen poplar and balsam poplar constitute a large portion of the forest growth both in the valleys and on the hillsides, but rarely have over 10 inch stumps, and the wood is of value mainly as fuel. Willows, dwarf birch, and alder occur plentifully both in the valleys and on the slopes, and the dwarf birch, in places, extends to the plateau-level, and, with the willows and alder, in places constitute so dense a growth that walking is made very difficult.

Several varieties of wild fruits were noted, of which crow or heather berries (*Empetrum nigrum*), are the most plentiful and are found abundantly in most places to above timber-line. As these berries are very juicy and palatable, they are much prized by mountain climbers in these northern districts. Low bush cranberries (*Vaccinium oxycoccus*), high-bush cranberries (*Viburnum pauciflorum*), red currants (*Ribes rubrum*), black currants (*Ribes hudsonianum*), gooseberries (*Ribes lacustris*), strawberries (*Fragaria cuneifolia*), raspberries (*Rubus strigosus*), blue berries (*Vaccinium uliginosum* and *V. caespitosum*), and Saskatoon berries (*Amelanchier florida*) also occur in many parts of the district.

Moose, caribou, sheep, and goat are somewhat plentiful in many localities. The caribou is the large giant variety, Osborn's caribou (*Rangifer osborni*); the goat is the white antelope goat (*Oreamnos montanus*); and the sheep are of two varieties—Dall's Mountain sheep (*Ovis dalli*), and the saddle-back or Fannin's Mountain sheep (*Ovis fannini*). Black, brown, and grizzly bears are also plentiful. The wolf, wolverine, beaver, otter, marten, and lynx are somewhat common. Ordinary red foxes as well as cross, black, and silver foxes are occasionally found. Ptarmigan are exceedingly plentiful, of which the rock ptarmigan (*Lagopus rupestris*) and white-tailed ptarmigan (*Lagopus leucurus*) are found above timber line and during the summer months live mainly on the highest, often snow-capped, summits. The willow ptarmigan (*Lagopus lagopus*) exist during the summer months at about timber line. Blue grouse or Richardson grouse (*Dendragopus Richardsonii*), fool hens or Franklin grouse (*Canachites franklinii*), willow grouse or Oregon ruffed grouse (*Bonasa umbellus sabini*) are fairly plentiful and an occasional prairie chicken or northern sharp-tailed grouse (*Pedioecetes phasianellus*) was also seen; these live mainly in the timber and preferably in the valley flats. Rabbits, which are periodically plentiful, have been almost extinct for the past three years, but during the past summer they were noticed to be again rapidly increasing in numbers.

The lakes are generally well supplied with fish, mainly lake trout, whitefish, and grayling. Grayling are also plentiful in many of the streams.

GENERAL GEOLOGY.

GENERAL STATEMENT.

Regional.

The main physiographic provinces of northern British Columbia, as previously mentioned, are co-extensive with those of Yukon and Alaska to ... , and follow in a general way the trend of the Pacific C... ...ing 2). As topographic features are often, to a certain ... expressions of the bed-rock structure and composition, it ... expected, that in all probability, the same general geological horizons which compose the cordillera in Alaska and Yukon might extend southerly and southeasterly through the northern portions, at least, of British Columbia, and to a limited extent this has been found to be true.

Dr. G. M. Dawson[1] has shown that there is a certain continuity and lithological uniformity along the strike of some of the geologic terranes in British Columbia. In addition, a geological map of

[1] Dawson, G. M., "Geological record of the Rocky Mountain region, Canada." Bull. Geol. Soc. Amer., Vol. 12, p. 60.

western Canada[1] compiled largely from the work of Dawson and McConnell, also shows that the distribution of the more important geologic features exhibits in a broad way, a marked parallelism, and agrees roughly with the main physiographic divisions. Brooks has further shown that this to some degree holds true in Alaska, although not to the same extent as farther to the southeast, and that certain of the larger geologic terranes extend through British Columbia, Yukon, and Alaska. In northern British Columbia this parallelism and to some extent conformity of geologic formations to the strike of the physiographic provinces are only apparent when a broad tract is considered, and are most evident when the entire northern portion of the Province is viewed.

The Coast range consists of an igneous complex of granitic rocks, largely granodiorites, intruded mainly as a great batholith more than 1,000 miles in length, that reaches from south of the 49th to nearly 100 miles north of the 60th parallel (the British Columbia and Yukon boundary). This batholith extends along the south-western and western portion of Taku Arm belt and is the one really prominent geologic feature that has any marked trend parallel to the coast line and the main physiographic features of northern British Columbia and southern Yukon. In fact the main belt of these granitic rocks coincides practically with the Coast Range topographic province, although in places these intrusives extend out into the Yukon plateau.

The formations composing the Yukon Plateau province in northern British Columbia and southern Yukon, in few places show any tendency to parallelism with the topographic terranes, but instead are generally very irregularly distributed throughout the district. Only a small portion of this tract has been mapped or at all closely studied, so that the geological information concerning it is very incomplete. Still, the general distribution of some of the larger subdivisions of the geological column has been ascertained and the formations are known to range in age from lower Palaeozoic or older to Recent.

The most ancient rocks consist of a series of pre-Devonian schists, gneisses, and limestones, which have suffered intense dyna-

[1] Geological map of the Dominion of Canada, Western sheet, No. 783, Geol. Surv., Canada.

are metamorphosed, and represent rocks of both sedimentary and igneous origin. They are chiefly or entirely of lower Palaeozoic age, but some members may possibly be Pre-Cambrian. They constitute mainly small isolated areas that occur along the eastern margin of the Coast Range batholith.

Irregular areas of variously coloured cherts also occur in places. These are more recent than the schists, gneisses, etc., but seem to be older than all the other rocks in the region, and since they occur intimately associated with slates they are considered to be of sedimentary origin, but may not be.

The sedimentary rocks, with the exception of those included in the unclassified metamorphic groups, can be divided into three classes: those of Palaeozoic, those of Mesozoic, and those of Quaternary age. The igneous rocks comprise both intrusive and extrusive members and range in age from approximately upper Palaeozoic to Recent.

The Palaeozoic sediments consist of a series, several thousand feet thick, composed mainly of Devono-Carboniferous limestones, slates, and quartzites, and possibly also include the cherts above mentioned. The lower members are chiefly quartzites and slates, with their associated cherts, and some limestone bands, whereas the upper beds are principally heavily bedded limestones. The limestones appear to be much more extensive than the lower members, and constitute important ranges, in some instances having a northwesterly trend parallel to that of the Coast range to the west. One such range borders Lewes river, chiefly along the eastern side, from its headwaters for a distance of over 100 miles.

The Mesozoic sediments consist of a conformable series of conglomerates, sandstones, greywackes, shales, tuffs, and breccias, of Jura-Cretaceous age, which cover extensive tracts, and have in places an aggregate thickness of as much as 6,000 feet. Toward the north, these beds gradually increase in extent and relative importance, while the associated volcanics decrease.

The Quaternary deposits consist of Pleistocene and Recent materials which are lithologically nearly identical, and, in some instances grade into each other. In most places geological studies have not proceeded far enough to allow of their differentiation. The Pleistocene accumulations consist of unconsolidated gravels, sands, [illegible] and 500 [illegible] the [illegible] [illegible] [illegible]. The Recent [illegible] [illegible] [illegible] and [illegible] [illegible] [illegible] the [illegible] [illegible] great [illegible] [illegible] volcanic [illegible], and [illegible] [illegible] the [illegible] that cover the greater part of the district.

The [illegible] rocks other than those [illegible] rocks [illegible] metamorphic [illegible] [illegible] mainly of [illegible] [illegible] and [illegible] tuffs [illegible] [illegible] [illegible], and [illegible] [illegible] the age of [illegible] it is only known that they are older [illegible] the Coast Range intrusives and newer than the Lower Palæozoic metamorphic rocks. Locally these are quite extensive.

The Coast Range intrusives, which consist mainly of granodiorites and form the great Coast Range batholith, occur also as outlying stocks in the plateau region to the east and north. These rocks are believed to have been intruded, for the greater part at least, in Jurassic time and constitute the most prominent, single geologic feature in northwestern British Columbia and southwestern Yukon.

Newer than the older members of the Coast Range intrusives [illegible] a wide-spread series of andesites and andesitic tuffs and breccias, some of which are contemporaneous with and some newer than the Jura-Cretaceous sediments. More recent than this andesitic series are certain late Tertiary or Pleistocene basalts occurring mainly [illegible] the form of extensive flows. One important development forms the walls of Miles canyon near Whitehorse. [illegible] these, in places are extensive accumulations of basalt tuff. A [illegible] of dikes and small stocks of granite and syenite-porphyry [illegible] [illegible] intruded at about this time, but it is not known whether [illegible] or after the basalts. The most recently consolidated [illegible] [illegible] rhyolites, trachytes, and latites, which [illegible] [illegible] [illegible] over the country in places, generally [illegible] [illegible] or less in thickness; they were accompanied by great [illegible] tuffs and breccias.

[1] In southern Yukon a layer in places as much as [illegible] [illegible] an area estimated to be of, at least, 25,000 square miles [illegible]

Local

Representatives of all the different groups of rocks that have just been described as occurring in the Coast Range and Yukon Plateau portions of northern British Columbia and southern Yukon, occur in Taku Arm belt, so that on account of the diversity of age and characters of the various formations comprising these groups, the geology of this area is intricate. The rocks include pre-Devonian amphibolites, schists, gneisses, and limestones; Devonian (?) cherts and slates, as well as andesites, diorite, diabase, and magnesite; Carboniferous limestones; Jurassic granitic intrusives; Jura-Cretaceous conglomerates, sandstones, shales, greywackes, and tuffs; Tertiary and Pleistocene (?) andesites, andesitic tuffs, granite-porphyries, basalt, basalt tuffs, rhyolites, and rhyolitic tuffs, and Quaternary sands, gravels, silts, till, peat, ground ice, muck, etc.

The oldest rocks known to occur in the district are included in the Mt. Stevens group which consists chiefly of schistose amphibolites, mashed basic volcanics, mica- and hornblende-gneisses, sericitic schists, quartzites and limestones. These occur mainly in the southwestern part of the area, in the form of a more or less connected belt generally from 7 to 10 miles wide, that extends along the eastern edge of the Coast range. The amphibolites are prevailingly finely textured, greenish rocks that vary in structure from decidedly fissile to slightly schistose. The mashed volcanics present the appearance of laminated andesites, are dark green in colour, generally fine-grained, and although quite schistose, in most places, break into irregular fragments. The gneisses are, in the main, greyish to greenish, medium to coarsely textured rocks of decidedly gneissoid habit, in which mica and hornblende are generally conspicuous components. The sericitic schists are light coloured, generally soft and friable, finely textured rocks possessing fissility in a high degree. The quartzites, in the few places in which they were encountered, are hard, fine-grained, only slightly schistose rocks ranging in colour from nearly white to pale greenish. The limestones occur in beds-

[1] What follows under this heading contains in condensed form all the main facts of the general geology of Taku Arm belt, and is written particularly for those readers who do not wish to follow the details of the geology, but rather wish to obtain in a few pages the main points concerning the subject, and so be in a position to turn at once to the chapter on economic geology.

generally less than 10 feet thick. [illegible] in thickness and are intimately associated with the crystalline members. They vary in colour from white to bluish, and in texture from crystalline to subcrystalline. All these Mt. Stevens members are much pleated and contorted, and so highly metamorphosed that in many places, the original characters of the rocks have been entirely destroyed and it is now impossible to decide even whether they are of igneous or sedimentary origin.

In early [illegible] time a great portion of Yukon and northern British Columbia, including the greater part at least of Taku Arm belt, was invaded by the sea and remained inundated until, at least, well into Carboniferous time, and several thousand feet of Devono-Carboniferous argillaceous, arenaceous, and calcareous sediments were deposited, and now constitute the slates and possibly also the cherts of the Taku group, and the Braeburn limestones.

The members of the Taku group outcrop [illegible] only three small areas and consist mainly of cherts and slates. The cherts range in colour from light and dark grey to black, grey and black varieties predominating, but in places on weathered surfaces they are reddish owing to the oxidation of small amounts of contained iron ores; they are also hard and brittle and break into sharp-edged, irregularly shaped, fragments. An analysis of a typical specimen of these cherts (See under Taku group) indicates that they are highly metamorphosed, siliceous sediments. The associated slates generally possess a well-developed slaty structure, cleave readily into thin plates, and are dark, or nearly black in colour.

The Braeburn limestones outcrop extensively in Taku Arm belt and compose the hills on both sides of Taku arm for 20 miles from Tagish lake. They are at least 3,000 feet thick, vary in structure from semi-crystalline to crystalline and range in colour from greyish blue to almost white.

The time interval between the Carboniferous and the beginning of the Jura-Cretaceous deposition is not represented by any sediments, and probably during this interval Atlin district was a part of a land area subjected to erosion and intermittent volcanic invasions.

In probably post-Carboniferous, pre-Jurassic time, andesites, andesitic tuffs, diabase, diorite, and magnesian rocks, all of which are considered as members of the Perkins group, invaded the older rocks and buried them in places under considerable thicknesses of lava and tufaceous material. Certain members of this group, however, may have originated as early as Devonian time. The Perkins rocks are of considerable prominence and extent, and are found in various places throughout the Yukon Plateau portion of the district. The andesitic rocks are invariably dark-green to almost black in colour, are finely-textured, and generally extremely hard and brittle. Only one small area of diabase was found and this consists of medium textured, dark green, distinctly holocrystalline rocks that consist mainly of basic plagioclase, uralite, and chlorite. The diorite also was found outcropping over only one small area, and is a holocrystalline, granular, greyish to greyish green, finely-textured rock in which plagioclase, hornblende, and augite are visible to the unaided eye. The magnesian rocks consist largely of feldspar, magnesite, and iron, and are finely-textured, light to dark green in colour, and have generally a schistose structure. Portions of these rocks are much more susceptible to weathering agencies than others, so that their exposed surfaces become very rough and are always iron stained owing to the oxidation of the contained iron-ore minerals.

A wide-spread crustal movement, possibly the greatest in the history of the district, occurred in Jurassic and probably late Jurassic time, and was accompanied by the injection of vast amounts of igneous material including a great part, at least, of the granitic rocks of the batholith composing the Coast range. This batholith is composed mainly of grano-diorites, considerable portions of which were, however, intruded at a later date and subsequent to the deposition of the Jura-Cretaceous sediments. These Coast Range intrusives in addition to constituting the Coast range also form numerous dykes and isolated, irregularly shaped areas in the plateau district to the east. They are prevailingly fresh and unaltered in appearance, and are predominantly greyish in colour, although sufficient orthoclase occurs in places to give them a somewhat pinkish or reddish aspect. In places these rocks are quite porphyritic and contain feldspar phenocrysts as much as 1½ to 2 inches in length.

At the close of the Jurassic disturbance a considerable area was above the sea, and what was probably a short period of erosion ensued. This was followed by a gradual sinking of the land in

Jura-Cretaceous time, and this continued until an extensive land mass including the greater portion at least of Taku Arm belt was submerged.

The materials accumulated in this Jura-Cretaceous sea, in Taku Arm belt, were chiefly such as have produced, upon consolidation, conglomerates, sandstones, shales, and greywackes, which have been classed as members of the Laberge series. This series also contains tuff and other materials apparently deposited upon land. The Tantalus conglomerate beds that overlie the Laberge rocks, also appear to be largely consolidated river gravels.

The rocks of the Laberge series outcrop over possibly one-third of the Taku Arm belt and consist of shales, sandstones, conglomerates, greywackes, tuffs, slates, and quartzites, which have an aggregate thickness of at least 5,000 feet. Only one small exposure of Tantalus conglomerate was found and there only the lower 30 feet of the beds remain, the overlying portions having been removed by erosion. All the important coal seams so far discovered in southern Yukon and northern British Columbia have been found either in or immediately under Tantalus conglomerate which is readily distinguishable from other somewhat similar rocks, since all the component pebbles consist of quartz, chert, or slate. The other conglomerates of the region contain various other materials such as granite, limestone, and fragments of various volcanic rocks.

This Jura-Cretaceous period was also characterized by volcanic activity, as evidenced by the tufaceous materials found intercalated with the normal sediments. These volcanics all appear to be andesitic in character and to be related to the Chieftain Hill volcanics which consist mainly of andesites and andesitic tuffs and breccias which have extensively invaded the Jura-Cretaceous sediments and in places buried them under great accumulations of lava, ashes, breccias, etc.

These Chieftain Hill volcanics in Taku Arm belt occur mainly in two areas, one of which extends from Taku Landing northwesterly toward the mouth of Tutshi river, and is 2 to 6 miles wide and possibly 25 miles long; the other area lies to the west of the Engineer mines and Edgar lake and is 4 to 6 miles wide and apparently about 10 miles long. Other small exposures and dykes were noted in various localities. These rocks are mainly mica-, hornblende-, an augite-andesites, and andesitic tuffs and breccias. They vary con siderably in mineralogical composition, and have a wide range o colour showing many shades of red, blue, green, and brown, but the generally possess a typical andesitic habit.

The Jura-Cretaceous sediments have been extensively invade by the Coast Range intrusives which are, in the field, indistinguish able in character from the granodiorite pebbles and boulders tha constitute, to a considerable extent, the lower conglomerate beds o the Laberge series. It is evident, therefore, that intrusions of grano diorite have occurred, apparently from the same magma, at differen and, in some cases, widely separated periods.

The Jura-Cretaceous period of sedimentation was terminated b a wide-spread deformation, at the close of which a considerable area including Taku Arm belt, and the greater part, at least, of norther British Columbia and southern Yukon, was above the sea. Degra dation became active, and no evidence has been obtained to show that from that time to the present, any portion of that region has bee subjected to marine conditions. The historic records in Taku Arm belt from the time of the Jura-Cretaceous disturbance until th glacial period are few and indefinite, and show mainly that th Jura-Cretaceous beds were considerably deformed and meta morphosed, that erosion continued until a nearly base-levelled surface was produced, and that this surface has been subsequently uplifted and dissected. Since, however, no sediments occur that are more recent than the Jura-Cretaceous beds and older than Pleistocene, there is no evidence within Atlin district to indicate either during what period the planated surface was elevated, or whether or not there has been more than one erosion cycle and subsequent uplift.

After the invasion of the district by the Chieftain Hill volcanics and during a period believed to include portions of the Tertiary and also perhaps of early Pleistocene, Taku Arm belt was subjected to at least three volcanic invasions—by the Carmack basalts, the Klusha intrusives, and the Wheaton River volcanics. The Car mack basalts appear to be the oldest of these rocks, and occur either as dykes injected into the older formations or, in places, as flows that poured over the land-surface, accompanied locally by tufaceous accumulations. Only two small exposures of extrusive basaltic materials were noted; and these occur, respectively, near Kirtland on the west shore of Taku arm, and on the southwest face of Armstrong peak. The basaltic rocks range from fine to medium in texture, and from dark-greenish to dark-reddish in colour. Many of them are heavily impregnated with iron-ore minerals, and in most specimens augite, olivine, and basic plagioclase are visible to the unaided eye.

The Klusha intrusives are represented in Taku Arm belt by numerous dykes of granite-porphyry, which cut the older formations and are of about the same age as the Carmack basalts, but whether younger or older is not definitely known. They are light grey to pinkish, coarsely crystalline rocks of granitic habit.

The Wheaton River volcanics are more recent than the Carmack basalts and consist of rhyolites and tuffs, which occur as dykes and also as flows and tufaceous accumulations. They are, typically, almost white to light yellow rocks, although in places they are iron stained, and decidedly red on weathered surfaces. The Wheaton River volcanics appear to be connected with the Klusha granitic intrusives and may be synchronous with them.

In upper Cretaceous time a transgression of the sea took place along the present Yukon basin to the north of Taku Arm belt, and also probably extended to other portions of Alaska and northern Yukon. Deposition continued well into the Eocene, although "in the Upper Yukon basin, the Eocene is represented only by fresh water beds which seem to have been laid down in isolated basins."[1] In Eocene or Miocene time, a gradual uplift occurred which, though of an orographic character, was accompanied by volcanic activity and by a considerable local disturbance of the Eocene beds. The exact date of this orogenic movement is somewhat in doubt. Dawson[2] refers the uplift to the Eocene, but Brooks[3] has produced considerable evidence to show that the dynamic revolution occurred during late Eocene or early Miocene time. A long period of crustal stability ensued, during which what is now the Yukon plateau, as well, possibly, as the Coast range and other adjoining tracts[4] were reduced to a nearly featureless plain which was subsequently elevated.

[1] Brooks, A. H. Prof. Paper, No. 45, U.S. Geol. Survey, 1906, p. 266.
[2] Dawson, G. M., "Geological record in the Rocky Mountain region of Canada," Bull. Geol. Soc. of Amer., Vol. 12, p. 79.
[3] Op. cit., pp. 292, 293.
[4] Spencer, A. C., "Pacific Mountain system in British Columbia and Alaska," Bull. Geol. Soc. of Amer., Vol. 14, April, 1903, pp. 117-132.

Dawson[1] maintains that the planation was accomplished during the Eocene epoch, that the Miocene was a period of vulcanism, deposition and accumulation, and Brooks[2] agrees with him in considering that the subsequent uplift occurred in Pliocene or early Pleistocene time. Spurr, however, shows that the erosion of the Yukon plateau was contemporaneous with the deposition of the Miocene strata in the lower valley of Yukon river, and, therefore, urges that the Yukon plateau was planated in Miocene time and was subsequently uplifted in late Miocene or early Pliocene time.[3] It is not known, to what extent Taku Arm belt was affected by these various movements and disturbances, but it is probable that the Jura-Cretaceous sediments were largely deformed by the Eocene or Miocene (post-Laramie) dynamic movements, that the district was peneplanated during Eocene or pre-Pliocene post-Eocene time, and that this planated tract was uplifted to practically its present position during late Miocene, Pliocene, or early Pleistocene time.

After the last great uplift of the district, the streams began rapidly trenching their valleys and soon deep V-shaped incisions resulted, and the water-ways and valley systems of to-day were established. It was after these depressions were well formed that the Carmack basalts and Wheaton River volcanics, and probably the Klusha intrusives as well, invaded the district.

At a later date the mountains to the west and south of Taku Arm belt became the gathering grounds for glaciers, and huge tongues of ice came down from them and occupied Taku Arm valley and its various tributaries. These depressions were deepened and widened by ice action, and vast amounts of morainal and other glacial accumulations were deposited on the floors and along the lower portion of the walls of the valleys.

Overlying these Pleistocene deposits are the Recent accumulations, composed of fluvial and littoral sands, gravels, and silts of the present waterways, muck, and soil.

[1] Dawson, G. M., Trans. Roy. Soc. of Can., 1890, Vol. VIII, Sec. 4, 1890, pp. 11-17.

[2] Brooks, A. H., Op. cit., pp. 290, 292, 293.

[3] Spurr, J. E., "Geology of the Yukon Gold district, Alaska," Eighteenth Ann. Rep., U.S. Geol. Surv., Pt. III, 1898, p. 260, 262, 263

TABLE OF FORMATIONS

Sedimentary Rocks

Age.	Formation.	Lithological characters.
Quaternary	Superficial deposits	Chiefly gravels, sands, boulder clays, silts, muck, peat, and soil
Jura Cretaceous.	Tantalus conglomerate	Conglomerate chiefly with some sandstone and shale
	Laberge series	Conglomerates, sandstones, greywackes, tuffs, shales, slates, and quartzites.
Carboniferous	Braeburn limestones	Limestones.

Igneous Rocks.

Age.	Formation.	Lithological characters.
Pleistocene to early Cretaceous—probably mainly Tertiary	Wheaton River volcanics	Chiefly rhyolites and rhyolitic tuffs
	Carmack basalts	Basalts and basalt tuffs
	Klusha intrusives	Chiefly granite porphyry
	Chieftain Hill volcanics	Chiefly andesites and andesitic tuffs and breccias
Jurassic (?)	Coast Range intrusives	Chiefly granodiorites.
Probably all upper Palaeozoic.	Perkins group.	Chiefly andesites, andesitic tuffs, diabase, diorite, and magnesite.

Unclassified Rocks.

Age.	Formation.	Lithological characters.
Devonian (?)	[illegible] group.	Cherts and slates.
Pre Devonian, probably all lower Palaeozoic	Mt. Stevens group	Chiefly schistose amphibolites, mashed basic volcanics, mica- and hornblende gneisses, sericite-schists, quartzites, and limestones.

DETAILED DESCRIPTIONS OF FORMATIONS

Mt. Stevens Group.

DISTRIBUTION.

The rocks of the Mt. Stevens group occur only in the southwestern part of Taku Arm belt, and there adjoin and lie to the east of the Coast Range intrusives which occupy the extreme southwest corner of the area. In fact, wherever in southern Yukon and northern British Columbia, the eastern edge of the Coast range has been explored, these Mt. Stevens rocks occur in the form of a more or less connected belt bordering the granitic intrusives. In Taku Arm belt, the Mt. Stevens members outcrop throughout an area which south of Taku arm is about 4 miles wide, and to the north is much wider, but how much so is not known, as its western edge lies without the surveyed belt. The area throughout which these rocks outcrop within the district is about 20 miles long in a northwesterly direction, and from 4 to 10 miles wide.

LITHOLOGICAL CHARACTERS.

The Mt. Stevens group consists of a complex mainly of amphibolites, mashed basic volcanics, mica- and hornblende-gneisses, sericite-schists, quartzites, and limestones, which in most places occur so intimately associated that it would be exceedingly difficult to separately map the individual members.

Schistose Amphibolites.—The schistose amphibolites are finely-textured, dark green, rocks that have everywhere a laminated structure, but are rarely fissile, and frequently break across the structural planes almost as readily as along them.

Under the microscope, thin sections of typical varieties are seen to consist largely of plagioclase, hornblende, and biotite, with some accessory iron-ore and considerable secondary chlorite and calcite, as well as some zoisite. About one-half of the rocks appear, in most cases, to be plagioclase, mainly acid plagioclase. The hornblende is the next most important constituent and occurs mainly as pleochroic shreds. A large number of irregular pieces of biotite are also generally present.

Mashed Basic Volcanics.—The mashed basic volcanics are prevailingly firm and compact, and appear, megascopically, as fine to medium textured, greenish rocks having an andesitic habit. They have always a laminated structure, never being fissile, however, and they may or may not cleave along their foliation planes, but generally break into sharp angular fragments.

Typical specimens examined under the microscope appear to be mashed andesites, and consist chiefly of plagioclase, a small amount of quartz, considerable fibrous chlorite, some calcite, and accessory iron-ore. In some sections distinct traces of a holocrystalline porphyritic texture are preserved, in which large plagioclase phenocrysts have been prominent. Fine particles of magnetite are also liberally peppered through the groundmass.

Gneisses.—The gneisses are greyish to dark greenish, medium to coarsely textured rocks which have a decidedly gneissoid habit, and in which orthoclase, plagioclase, and either biotite or hornblende or both, can be readily detected with the unaided eye.

Under the microscope these rocks are seen to consist largely of orthoclase, microcline, plagioclase, biotite, hornblende, epidote, chlorite, and accessory iron-ore. The feldspars vary considerably in relative amounts; in some specimens the alkali feldspars predominate, but in others the lime-alkali feldspars constitute the greater portion of the rock mass. Chlorite and epidote as well as zoisite are generally prominent, and in some sections the original ferro-magnesian minerals have been entirely replaced. Generally, however, varying amounts of biotite and hornblende still remain.

Sericite-Schists.—The sericite-schists are light grey, fissile rocks which are generally somewhat soft and friable, and have prevailingly a bright, glistening, appearance, due to the great amount of sericite they contain. In places these rocks contain considerable iron-ore which oxidizes and gives them a decidedly reddish colour.

Microscopically these schists are seen to consist mainly of quartz and sericite, but contain also some orthoclase, plagioclase, and secondary calcite. The original feldspars have been for the greater part alkali feldspars, and are largely replaced mainly by sericite and to some extent also by calcite. The rocks appear to have been mainly rhyolites that have been mashed and sheared, and so transformed into their present form.

Quartzites.—The quartzites normally are light greyish to almost white in colour, but are in places stained reddish by limonite. These rocks have generally a fine gneissoid structure, and megascopically appear to consist entirely of quartz.

Thin sections examined under the microscope, however, are seen to consist chiefly of irregularly shaped, quartz grains, intergrown with which are some of alkali feldspar that are much altered to sericite. A few grains of plagioclase also occur, but are mainly transformed to calcite. Numerous shreds of brown biotite, as well as some accessory zircon and magnetite, were also noted.

Limestones.—The limestones vary from white to light-bluish, and from subcrystalline to crystalline, and can generally be distinguished for a long distance on account of their light colour. In places they are somewhat argillaceous, but are more frequently siliceous in composition. They generally occur in massive beds 10 to 50 feet in thickness, but in some places, where considerable admixtures of argillaceous matter occur, they become somewhat flaggy.

STRUCTURAL RELATIONS.

All these schistose and gneissoid rocks of the Mt. Stevens group have been subjected to folding, faulting, mashing, shearing, and distortion, and have been so metamorphosed that in many places their original characters have been masked or even totally destroyed. Even the limestones are folded, crumpled, and so involved with the other members, that their relative ages are uncertain.

These rocks invariably occur along the eastern edge of the Coast Range intrusives, and wherever found in Taku Arm belt, constitute portions of the walls of the Coast Range batholith.

AGE AND CORRELATION.

In Taku Arm belt no fossils have been found in the members of the Mt. Stevens group, and it is only known that these comprise the oldest rocks exposed in the area. However, from the descriptions of McConnell[1] in Dawson district, and of Brooks[2] and others in Alaska, it is evident that the Mt. Stevens rocks correspond with the lower Palaeozoic terranes of those districts. Different members of McConnell's 'Older Schistose Rocks' are lithologically apparently quite similar to those of the Mt. Stevens group. The gneisses appear to correspond to the Pelly gneisses,[3] at first considered to be Archaean, but now believed to be much more recent, and probably Palaeozoic. Certain limestone bands carrying Silurian fossils occur intercalated in the schistose rocks in Alaska, and these limestones, both in their association and occurrence, resemble those in Taku

[1] McConnell, R. G., "The Klondike gold fields," Ann. Rep., Geol. Surv., Can., Vol. XIV, p. 17. 1901.

[2] Brooks, A. H., "The geography and geology of Alaska," U.S. Geol. Surv., Prof. Paper, No. 45, 1906, pp. 208-218.

[3] McConnell, R. G. The American Geologist, Vol. XXX, July, 1902.

Arm belt. The Mt. Stevens group is thus considered to be pre-Devonian, and probably all lower Palaeozoic.

The name Mt. Stevens group was first applied in Wheaton district,[1] Yukon, where these rocks outcrop somewhat extensively. In the writer's report on the 'Lewes and Nordenskiöld Rivers coal area,' Yukon, rocks are also described under the name 'Razor Mt. group,' that in all probability correspond to the Mt. Stevens group, but since only a single small outcrop occurs there, the correlation is somewhat uncertain.

The members included under division IX on Prof. Gwillim's[2] map, and in his report on Atlin mining district, also correspond to those of the Mt. Stevens group.

Taku Group.

DISTRIBUTION.

Outcrops of rocks belonging to the Taku group are limited in Taku Arm belt to three small areas, the largest of which is situated on the northern end of Peninsula mountain. This area is about 2 miles long in a northwestern direction, and has an average width of about one-half mile. The Taku rocks also occur throughout an area possibly three-fourths of a mile in diameter, situated at the southeastern corner of Turtle lake, and thus about 2½ miles in a southeasterly direction from the larger area. A third small area, apparently only a few hundred feet in diameter, occurs on the south shore of Taku arm, opposite the mouth of Tutshi river. Owing to the presence of superficial deposits the size of the two smaller areas is only approximately estimated.

LITHOLOGICAL CHARACTERS.

The members of the Taku group in Taku Arm belt are mainly cherts and slates. The cherts range in colour from light and dark grey to black, but in places they are reddish on weathered surfaces, due to the oxidation of small amounts of contained iron ore. These

[1] Cairnes, D. D., "Wheaton district, Yukon," Geol. Surv., Dept. of Mines, Memoir No. 31, 1912.

[2] Gwillim, J. C., "Report on Atlin mining district, British Columbia," Geol. Surv., Can., Ann. Rep., Vol. XII, 1899, Part B, p. 16.

rocks are massive, hard, and brittle, and break into sharp-edged, irregularly shaped, fragments. The origin of the cherts is not definitely determinable from their lithological characters, but since they occur more or less intimately associated with the slates of the Taku Arm group, they are thought to be probably, for the greater part at least, highly metamorphosed siliceous sediments. A typical sample of these cherts was analysed by the Mines Branch of the Department of Mines, showing the rock to contain as follows:—

SiO_2	96.82
Al_2O_3	1.10
Fe_2O_3	0.55
FeO	0.37
MgO	trace
MnO	trace
CaO	trace
Na_2O	0.30
K_2O	0.26
H_2O (at 110° C)	trace
H_2O (above 110° C)	0.30
TiO_2	0.05
P_2O_5	0.01
CO_2	
Organic matter	small percentage
Total	99.76
Specific gravity	2.64

This also indicates that these cherts are of purely sedimentary origin.

The associated slates generally possess a well-developed slaty structure, cleave readily into thin plates, are dark or nearly black in colour, and are folded, broken, and distorted.

AGE AND CORRELATION.

The rocks of the Taku group underlie the Carboniferous (?) Braeburn limestones and appear to correspond with the members of Dr. Dawson's Lower Cache Creek series[1], of more southerly portions of British Columbia; they have, therefore, been considered to be probably of Devonian age.

These rocks also occur in Windy Arm district, Yukon[2], and were there referred to the Lower Cache Creek group. Since, how-

[1] Dawson, G. M., Rep. of Prog., Geol. Surv., Can., 1876-77, pp. 55-58.
Dawson, G. M., Ann. Rep., Geol. Surv., Can., Vol. III, Pt. B, 1887-88, pp. 170-171.
Dawson, G. M., Ann. Rep., Geol. Surv., Can., Vol. VII, Pt. B., 1894, pp. 37-49.

[2] Cairnes, D. D., "Portions of Conrad and Whitehorse mining district," Geol. Surv., Dept. of Mines, Can., 1908, pp. 26-29.

ever, this correlation was made entirely from Dr. Dawson's descriptions and without the writer having seen the original Lower Cache Creek rocks, it seems possible that the two groups may not altogether correspond, and the new name Taku group has, therefore, been adopted in Taku Arm belt.

This group corresponds to division VIII on Gwillim's map, and in his report on Atlin mining district.

Braeburn Limestones.

DISTRIBUTION.

Braeburn limestones occupy the entire northeastern corner of Taku Arm belt and are extensively developed thence to the north and east. They thus extend up Taku arm to the mouth of Tutshi river on the west shore, and continue southeasterly to include the northeastern part of Peninsula mountain, and the hills immediately to the east of Sunday peak.

LITHOLOGICAL CHARACTERS.

These limestones are generally finely textured and range in colour from greyish blue to almost white. They also vary from subcrystalline to crystalline in structure, but are prevailingly in the state of marble, and many specimens are handsomely and curiously marked with grey and black lines and spots. Some beds contain considerable silica and weather rough, and occasional layers, particularly near the bottom of the series, are composed largely of cherty material. These limestones are over 3,000 feet in thickness, and are generally heavily bedded, and considerably metamorphosed, so that in only rare cases are definite bedding-planes distinguishable.

AGE AND CORRELATION.

The name 'Braeburn limestones' was first applied in the Braeburn-Kynocks area[1] from where these rocks have been traced continuously to Taku Arm belt. These limestones are also the same as those included under the Upper Cache Creek series of Conrad

[1] Cairnes, D. D., "Preliminary memoir on the Lewes and Nordenskiold Rivers coal district, Yukon Territory," Geol. Surv., Dept. of Mines, Can., Memoir No. 5, 1910, pp. 28-30.

mining division. This name, however, was given believing these beds to correspond to Dr. Dawson's Upper Cache Creek rocks[1] in British Columbia, but since the correlation was made entirely from the descriptions of the beds, it appears possible that the rocks in these widely separated districts may not all belong to the same horizon, and the new name has therefore been given.

Dr. Dawson, however, collected Fusulinae from the limestones which extend along the east side of Windy arm, showing these beds at least to be Carboniferous, so the whole series is thought probably to belong to this age, although no other fossil remains of a definite character have been discovered.

Perkins Group.

DISTRIBUTION.

Only five small developments of the members of the Perkins group were noted in Taku Arm belt, and these are all situated north of Graham inlet and east of Taku arm. The largest area occurs on the hill immediately west of Table mountain, and is about 2 miles long measured in a north direction, by three-fourths of a mile wide. A small exposure, apparently less than 500 feet in diameter, appears on the north shore of Graham inlet about 6 miles west of Taku Landing. A third small area about 200 feet in diameter occurs on the southwestern corner of Sunday mountain. A fourth development about 1½ miles long in a northwesterly direction, by one-half mile wide, lies south of Peninsula mountain, and a considerable portion of the extreme southern end of Peninsula mountain itself, is composed of these rocks.

LITHOLOGICAL CHARACTERS.

The members of the Perkins group consist chiefly of andesites, andesitic tuffs, diabase, diorite, and magnesite.

Andesites and Andesitic Tuffs.—The andesitic members have been identified only on Peninsula mountain, and are there for the greater part heavily iron-stained and considerably decomposed on

[1] Dawson, G. M., Rep. of Prog., Geol. Surv. Can., 1876-77, pp. 55-58.
Dawson, G. M., Ann. Rep., Geol. Surv., Can., Vol. VII, Pt. B, 1894, pp. 37-49.

[2] Dawson, G. M., Ann. Rep., Geol. Surv., Can., Vol. III, Pt. B, 1887-88, pp. 170-171.

the surface. Where they are not so weathered and impregnated with iron oxide they are from finely textured, greenish to reddish-brown rocks. In places they are quite homogeneous in appearance; in others they are breccias or tuffs with a decidedly mottled aspect. This mottled appearance is due to particles of andesite of varying textures being embedded in a groundmass of andesite differing in appearance from the enclosed pieces which range in size from microscopic particles to fragments a foot or more in diameter. These andesitic rocks are generally megascopically aphanitic although sometimes phenocrysts discernible with the naked eye have developed.

Microscopically these are seen to be porphyritic rocks containing phenocrysts of plagioclase, hornblende, diopside, and biotite lying in a hypocrystalline or holocrystalline groundmass. The feldspar of the first generation is prevailingly labradorite, but ranges from andesine to bytownite, and exhibits twinning according to the albite, pericline and Carlsbad laws. Zonal structures are also of frequent occurrence and represent variations in the amount of lime present. The phenocrysts are generally abundant and well formed, and range in size from those entirely invisible macroscopically to others ⅛ of an inch long. Common green hornblende is the most abundant of the coloured constituents, and is generally present. Biotite occasionally occurs associated with the hornblende, but in places is the only ferromagnesian mineral in the rock, while diopside is found only rarely. Accessory apatite and magnetite are common.

The groundmass has frequently a pilotaxitic fabric, and consists of a felt-like web of plagioclase needles, hornblende or diopside crystals, and iron ore grains. Often a certain amount of brownish glass is mixed with these other materials giving the groundmass a hyalopilitic structure.

The rock constituents are, in most cases, considerably altered, so that the rocks consist to a great extent of chlorite, epidote, calcite, serpentine, quartz, and iron ore, which latter is frequently peppered plentifully throughout the groundmass. These alteration features serve, in places, to distinguish these rocks from the Chieftain Hill volcanics.

Diabase.—Diabase was found only in the one small area, about 300 feet in diameter, on Sunday mountain, and is a massive, firm, dark greenish to greyish-green, medium textured, rock that megascopically is seen to be holocrystalline, and to consist largely of plagioclase and a dark ferromagnesian mineral.

Under the microscope the rock proves to be composed largely of basic plagioclase, uralite, chlorite, zoisite, apatite, ilmenite, and its alteration product leucoxene, and magnetite. The greater part of the rock mass consists of plagioclase and uralite, with also considerable chlorite. The rock possesses quite a decided ophitic structure and hence is given the name diabase.

Diorite.—Diorite was found in Taku Arm belt in only one locality which is situated just west of Table mountain. This is, megascopically, a holocrystalline, granular, greyish to greyish green, homogeneous, finely textured rock in which feldspar and hornblende are distinctly visible.

Microscopically this rock is seen to consist largely of plagioclase, hornblende, augite, chlorite, and accessory iron ore. The greater part of the rock is composed of plagioclase which is prevailingly in allotriomorphic prismatic pieces. The hornblende occurs as numerous long brownish shreds with indefinite terminals, and also as diamond shaped idiomorphic to hypidiomorphic grains. A few augite individuals occur but are generally much altered, mainly to epidote. The chlorite is largely derived from the amphibole.

Magnesian Rocks.—Magnesite and related rocks high in magnesia, occur in two localities, viz., on the north shore of Graham inlet 3½ miles west of Taku Landing, and immediately to the south of the southern end of Peninsula mountain. These rocks weather rough and are, in most places, heavily iron-stained. On fresh fractures, however, they are greyish to dark greenish in colour, and are seen to be finely textured, and to have generally a schistose structure. A considerable portion of these rocks, and in places bands several inches wide, consist of almost pure magnesite.

Under the microscope these magnesian rocks are seen to consist mainly of plagioclase and magnesite. All the feldspar has wavy extinction, and exhibits a consertal fabric, the particles being interfingered together. The magnesite shows a decided tendency to be crystalline, and has dominantly largely a consertal arrangement. The rocks also contain subordinate amounts of calcite, dolomite, epidote, and iron ore, and have been mashed and given a schistose structure. They all appear to be much altered igneous intrusives high in magnesia.

AGE AND CORRELATION.

Concerning the age of the members of the Perkins group, it was only definitely determined, in Taku Arm belt, that they are all younger than the Mt. Stevens group which is considered to be pre-Devonian, and are older than the Jura-Cretaceous sediments and Coast Range intrusives. The Laberge series contains many pebbles of the Perkins rocks, and in several places the Coast Range granitic rocks were noted to cut them. The rocks correspond to the Perkins group of rocks in Wheaton district, Yukon,[1] where the name was first adopted. The andesitic members also are probably of the same age as the rocks in Whitehorse district described by McConnell as 'Porphyrites'[2] and which are more recent than the Carboniferous limestones.

[1] Cairnes, D. D., "Wheaton district, Yukon," Geol. Surv., Dept. of Mines, Can., Memoir No. 31, 1912.

[2] McConnell, R. G., "The Whitehorse Copper belt, Yukon Territory," Geol. Surv., Dept. of Mines, Can., 1909, pp. 9-12.

The Perkins rocks also correspond closely to the 'Gold series' described by Gwillim in his report on Atlin mining district; the Gold series, however, appears to include under 'greenstones' andesitic rocks which are more recent than the Perkins rocks and are in this memoir included under the Chieftain Hill volcanics.

In the writer's report on 'Portions of Conrad and Whitehorse mining districts,' rocks corresponding to members of the Perkins group are included in the Lower Câche Creek series, considered as being of Devonian age; but since Mr. McConnell's work in Whitehorse Copper belt, it appears that at least the andesitic, and possibly other members as well of the Perkins group are post Carboniferous, pre-Jurassic, so all have been provisionally placed under upper Palæozoic. It is possible, however, that some members, the diabase or magnesite for example, may be as old as Devonian.

Coast Range Intrusives.

DISTRIBUTION.

All the extreme southwestern corner of Taku Arm belt consists of the Coast Range intrusives which also form a considerable portion of the top of Lanning mountain and the high ridge to the south of Racine lake. Besides these larger areas a number of smaller exposures a few hundred or a few thousand feet in diameter occur in various localities through the district. These rocks also compose the Coast range of mountains lying to the west of the district and are probably the most extensive individual geological terrane in northwestern British Columbia or southwestern Yukon.

LITHOLOGICAL CHARACTERS.

The Coast Range intrusives are for the most part fresh and unaltered in appearance, are predominantly greyish in colour, and have the general appearance of typical, medium to coarsely textured granites. The orthoclase is, locally, sufficiently prominent to give these rocks a pinkish colour, but this is exceptional. In places these intrusives become porphyritic in structure and contain numerous large feldspar phenocrysts as much as 1½ to 2 inches in length. Hornblende, biotite, and augite, are generally present and are in most cases readily visible to the unaided eye.

When examined under the microscope, most sections of these rocks are seen to consist chiefly of alkali feldspar, an acid lime-alkali feldspar, quartz, hornblende, biotite, and augite. Both orthoclase and microcline generally occur and together are characteristically about equal in amount to the acid plagioclase. The feldspars frequently exhibit zonal structures showing these individuals to vary in composition from the centre outwards.

The hornblende, biotite, and augite are, in typical sections, about equal in amount, although occasionally one or even two of these minerals may be missing. The hornblende and augite are in places intimately intergrown, and the biotite usually occurs as large fresh individuals, all these minerals being prevailingly allotriomorphic. In addition, zircon, apatite, and magnetite are frequent accessories. The rocks have either a typical granitic structure or contain large feldspar phenocrysts in a granitic groundmass and so have a holocrystalline porphyritic structure.

These intrusives thus have predominantly a mineralogical composition midway between a granite and a quartz diorite, and have been called grano-diorites. In places in the Coast range, with increasing orthoclase and decreasing plagioclase and augite, typical granites have been noted; also locally the plagioclase and augite increase and the orthoclase disappears, giving rise to diorites. Such extremes were not found, however, in Taku Arm belt. Occasionally with the introduction of a porphyritic structure, these granitic rocks might be almost equally well termed either porphyritic grano-diorites or grano-diorite porphyries; but since the rocks everywhere are coarsely textured and always have a typical granitic habit, the term porphyritic grano-diorite seems preferable in all cases. Similarly porphyritic granites and diorites may occur.

A typical specimen of these intrusives was analysed by the Mines Branch of the Department of Mines, giving as follows:—

SiO_2	69·08
Al_2O_3	13·93
Fe_2O_3	2·72
FeO	1·62
MgO	0·80
CaO	3·38
Na_2O	3·55
K_2O	3·99
H_2O (at 110°C.)	0·03
H_2O (above 110°C.)	1·05
TiO_2	0·23
P_2O_5	0·07
CO_2	
MnO	trace
Total	100·45

Specific gravity=2·69.

This analysis indicates that this particular specimen might be termed either a calcic granite or a grano-diorite, but under the microscope, as described above, the rock appears to be decidedly a grano-diorite.

The term monzonite has been adopted by the United States geological survey, and is used by many geologists both in Canada and the United States for rocks midway in composition between granites or syenites, and diorites, and according to this nomenclature these rocks are prevailingly quartz monzonites, and porphyritic quartz monzonites.

The name Adamellite has been used by Brogger[1] as a convenient term to signify an acid quartz monzonite.

In places, as on the northeastern corner of Mt. Clive, basic differentiation products of the granodiorites occur as dykes cutting the granodiorites and the surrounding Laberge beds. An average sample of one such dyke examined under the microscope proved to be a hornblende kersantite and is a typical hypidiomorphic dyke rock consisting mainly of plagioclase, biotite, and hornblende. The plagioclase occurs in long, lathe-like, allotriomorphic or hypidiomorphic forms of very uniform size. The biotite and hornblende occur as allotriomorphic particles scattered between the feldspars which form a sort of web or base containing them. The Klusha intrusives are probably the later acid differentiation products of the grano-diorites.

AGE AND CORRELATION.

These granitic intrusives which compose the Coast Range batholith, have been studied by geologists in British Columbia, Alaska and Yukon, and there appears to be a general consensus of opinion that they were intruded in about Jurassic time. In Taku Arm belt, however, although large pebbles and boulders of these intrusives occur in the lowest beds of the Jura-Cretaceous Laberge series, yet wherever contacts have been discovered between these sedimentaries and the intrusives the granitic rocks distinctly cut even the uppermost Laberge beds, showing that the Coast Range rocks, although they are all lithologically very similar, were intruded at different times, separated by wide time intervals. The greater part, at least, of these rocks in Taku Arm belt are more recent than the Laberge beds, all of which appear to be Jurassic or Jurassic and possibly lower Cretaceous.

Laberge Series.

DISTRIBUTION.

The Laberge series is the most extensive geological terrane in Taku Arm belt, and its members outcrop in a general way through-

[1] Brogger, W. C. "Die Eruptionsfolge der triadischen Eruptivgesteine bei Predazzo in Sudtyrol," p. 61.

out the central, southwestern, and northwestern portions of the district. The group of hills east of Taku arm and south of Graham inlet; the greater part of the area north of Fantail lake and south of Tutshi lake, on the west side of Taku arm; and Sunday mountain and the western portion of Taku mountains, are all largely composed of these rocks.

LITHOLOGICAL CHARACTERS.

The Laberge series consists of shales, sandstones, conglomerates, greywackes,[1] tuffs, slates, and quartzites, which have an aggregate thickness of at least 5,000 feet. Possibly the most conspicuous members are greyish to greenish, finely textured to medium grained, homogeneous looking, massive rocks, which in many cases exhibit no distinct bedding planes, except when viewed from a distance, and are in places with difficulty distinguished from some of the Chieftain Hill volcanics to which they appear to be directly related. These beds constitute the greater part of the upper portions of the Laberge series and occur, also, but to a less extent, lower down. They are apparently predominantly pyroclastics but grade into ordinary water-laid sediments. Associated with these greenish rocks, in places, mainly in the lower third of the series, are numerous beds of dark grey to almost black, generally friable, shales, accompanying which are numerous bands, generally only a few inches in thickness, of finely textured, brownish sandstones.

The middle portion of the series is characterized by shales that are in most places heavily iron-stained on weathered surfaces, and can be distinguished for long distances. When broken, however, they are generally seen to range from light grey through dark green to almost black in colour, and are hard and brittle, and break generally into sharp angular fragments. They occur prevailingly in layers one-fourth to 1 inch in thickness, and are associated to some extent with greywackes and sandstones, but the shales predominate.

[1] In this memoir the term greywacke is intended to include consolidated sediments consisting mainly of prevailingly angular fragments of feldspars, quartz, mica, and perhaps hornblende and augite, as well as of various rocks, all in a groundmass having about the composition of a clay slate. The term sandstone, on the other hand, includes those consolidated sediments that consist largely of quartz grains bound together with some simple cement such as calcite or silica.

Below the reddish shale horizon the beds are dominantly greenish greywackes and intercalated dark grey to almost black, generally soft, somewhat friable shales. Near the bottom of the series are some characteristic, coarse, conglomerate beds, the constituent pebbles and boulders of which are mainly granodiorite, limestone, and greenish igneous rocks derived apparently from the Perkins group. Boulders 6 to 8 inches in diameter are of common occurrence, and some were noted as much as 2½ feet long.

In the vicinity of intrusive rocks, particularly the Coast Range intrusives, the Laberge beds become hard, dense, quartzitic, and cherty. On Mt. Clive, Mt. Lanning, and elsewhere, for over 50 feet from the granitic rocks, the Laberge beds are distinctly crystalline and in places hard and quartzitic. In places, also, pressure has altered the shales into true slates.

Under the microscope the greenish, medium textured rocks are seen to consist largely of angular fragments of feldspar, hornblende, biotite, augite, quartz, and volcanic rocks, and also contain particles of iron ore. In some specimens there has been almost complete disintegration of the parent rock into its component minerals, but in other places this process is less advanced. With increasing amounts of volcanic materials these rocks grade into distinct tuffs in which fragments largely of volcanic rocks, but also of v[illegible]its of feldspar, quartz, hornblende, etc., occur in a volcanic gr[illegible]. The rocks that consist largely of sedimentary materials are class[illegible] as greywackes, but where the volcanic matter predominates they are considered to be tuffs. In places these rocks are greatly altered mainly to calcite, kaolin, and chlorite.

MODE OF ORIGIN.

Considerable portions of the Laberge series are undoubtedly ordinary water-lain sediments, but volcanic fragments are in places very plentiful and increase in amount in places, to the almost complete exclusion of the sedimentary materials. It appears probable that volcanism was active during Jura-Cretaceous sedimentation, and that showers of ashes and breccia fell into the sea and on the land, and became both directly and indirectly associated with the land and water sediments. Some of the Laberge beds were deposited in the sea, as they contain marine fossil remains, but considerable portions appear to have been deposited on the land largely by stream-action. These beds are characterized by occasional isolated and widely separated pebbles, up to several inches long, included in a fine groundmass. Pebbles in sea-shore deposits invariably occur close together and are of somewhat uniform size, due to the sorting action of the water.

AGE AND CORRELATION.

The name Laberge series was first applied in the Braeburn-Kynocks coal area,[1] where beds occur very similar to those in Taku Arm belt, and in these a number of poorly preserved fossils were discovered which were examined by Dr. Whiteaves, who classed them as Jura-Cretaceous. These beds are overlain in the Taku Arm belt by Tantalus conglomerate from which plant remains, determined to be of Kootanie age, were collected. This would indicate that the Laberge series are entirely Jurassic.

In Wheaton district, Yukon, numerous specimens of *Prionocyclus woolgari* have been found in the shales on Mt. Follé and Idaho hill, of which Dr. Whiteaves said: '*Prionocyclus woolgari* (Mantell) several crushed specimens of an ammonite, that are possibly very young individuals of this species. In the upper Missouri country, and elsewhere in the United States, *P. woolgari* is regarded as a characteristic fossil of the Fort Benton group.'

On Bee peak, in Taku Arm belt, a few poorly preserved specimens of *P. woolgari* were also found.

The Laberge series, together with the overlying Tantalus conglomerate, correspond to division III on Gwillim's map, and in his report on Atlin mining district.[2] Gwillim collected fossils from these rocks on Atlin lake, of which Dr. T. W. Stanton writes: 'These may possibly be Triassic, but I think it more probable that they are early Jurassic. They are certainly not so late as the Cretaceous.'

The information concerning the age of these beds is thus very fragmentary and to some extent conflicting, but the weight of evidence seems to point to a Jurassic age for the greater portion, at least, of the series. Until more information is obtained, therefore, the series may best, perhaps, be considered as Jura-Cretaceous.

The Laberge series also probably corresponds closely to Dr. Dawson's Jackass Mountain group[3] which, however, appears to include the coal-bearing Tantalus conglomerate. These rocks are

[1] Cairnes, D. D., "The Lewes and Nordenskiold Rivers coal district, Yukon Territory," Geol. Surv., Dept. of Mines, Can., Memoir No. 5, 1910, pp. 30-35.

[2] Gwillim, J. C., "Report on the Atlin mining district, British Columbia," Geol. Surv., Can., Ann. Rep., Vol. XII, 1899, Pt. 3, pp. 23-27.

[3] Dawson, G. M., Rep. of Prog., Geol. Surv., Can., 1875-76, pp. 253-256.

also a part of Dr Dawson's Porphyrite series,[1] which in addition includes great amounts of andesitic rocks corresponding apparently to the Chieftain Hill volcanics. Mr Leach has described the Porphyrite series[2] in the Bulkley valley, and in the Skeena River district has given the name Hazelton group[3] to these rocks.

Tantalus Conglomerate.

DISTRIBUTION.

Only one small exposure of Tantalus conglomerate was found in Taku Arm belt; this occurs on a small summit on the south side of Graham inlet about 5 miles southwest of Taku Landing, and is not more than a few hundred feet in diameter. Similar rocks also occur near Sloko lake and probably at other points in Atlin mining district.

LITHOLOGICAL CHARACTERS.

Tantalus conglomerate beds consist almost entirely of conglomerate, the component pebbles of which are all quartz, chert, or slate. These rocks can thus be readily distinguished from other conglomerates in the district, all of which contain pebbles of various materials, such as, limestone, granitic rocks, volcanic rocks, etc. The Tantalus conglomerates are prevailingly homogeneous in appearance, dark in colour, and even in texture, the component pebbles being rarely over 2 or 3 inches in diameter. Associated with, and intercalated in these conglomerates are a few shale beds, and in most other places where any considerable portion of the conglomerate section has been seen, coal seams have been found.

In Tantalus coal area the conglomerates are over 1,000 feet in thickness, but in Taku Arm belt erosion has removed all but about 30 feet of the beds, and the portion remaining does not contain coal. The great thickness of these conglomerates, alone is a strong indication that they are continental deposits.[4]

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[1] Dawson, G. M., Rep. of Prog., Geol. Surv., Can., 1876-77, pp. 58-72.

[2] Leach, W. W., "The Telkwa river and vicinity, B.C." Geol. Surv., Can., 1907, pp. 10, 11.

Leach, W. W., Sum. Reports, Geol. Surv., Dept. of Mines, Can., 1907, p. 20; 1908, p. 41.

[3] Leach, W. W., Sum. Rep., Geol. Surv., Dept. of Mines, Can., 1910, p. 61.

[4] Barrell, Joseph, "Relative geological importance of continental, littoral, and marine sedimentation," Jour. of Geol., Vol. XIV, Nos. 4, 5, and 6.

AGE AND CORRELATION.

No fossils were found in these beds in Taku Arm belt, but they overlie the Laberge rocks, apparently conformably.

The name Tantalus conglomerate was first applied in Tantalus coal area[1] where these rocks are of considerable economic importance on account of the coal they contain. Fossil plants were collected from the coal seams at the Tantalus mine, and were examined by Dr Penhallow, who says: 'All the specimens from the Tantalus mine present a flora with the same facies as those from the Nordenskiold river, and the whole conform to the flora of Kootanie age.[2]'"

Tantalus conglomerate occurs in Wheaton district also, where it contains valuable seams of coal.

A conglomerate having the lithological characteristics of the Tantalus conglomerate occurs in Moose Mountain district,[3] Alberta, and is there considered to be the lowest member of the Dakota formation, and directly overlies the Kootanie which contains the most valuable coal seams of the district. The conglomerate there is generally from 10 to 40 feet in thickness.

Similar conglomerates have been found by Mr. Leach[4] in Bulkley valley associated with valuable coal seams, but are there over 200 feet in thickness. Similar conglomerates and possibly of the same age have been described by Dr. Dawson and included in his Jackass Mountain group and Porphyrite series, referred to under Laberge series. These beds thus appear to have a wide distribution in British Columbia and Alberta and to increase in thickness towards the north.

Chieftain Hill Volcanics.

DISTRIBUTION.

The most important development of Chieftain Hill volcanics occurs as a northwesterly trending belt, 1 to 6 miles wide and about 20 miles long, extending from the southern edge of Table mountain

[1] Cairnes, D. D., "Preliminary memoir on the Lewes and Nordenskiold Rivers coal district, Yukon Territory," Geol. Surv., Dept. of Mines, Can., Memoir No. 5, 1910, pp. 35-39.

[2] The Kootanie is by some regarded as lower Cretaceous, but is generally assigned to the Jura-Cretaceous, and is considered to be either lower Cretaceous or upper Jurassic.

[3] Cairnes, D. D., "The Moose Mountain district, Alberta," Geol. Surv., Can., 1907, pp. 31-33.

[4] Leach, W. W., Sum. Reports, Geol. Surv., Dept. of Mines, 1907, 1908

on Graham inlet to the westward, and on Peninsula mountain near [illegible] Taku arm. The only other area in which these rocks were noted, except as dykes, includes the summit of Cloaner mountain, and the adjoining peak to the north.

LITHOLOGICAL CHARACTERS.

The Chieftain Hill volcanics are mainly mica-hornblende, and augite andesites, and andesitic tuffs and breccias. They vary considerably in appearance and composition, showing many shades of red, blue, green, and brown, but generally have an andesitic habit. A distinct porphyritic structure is prevailingly noticeable, and phenocrysts commonly of feldspar and more rarely of hornblende and biotite are generally visible. On Ear mountain and elsewhere, however, dark-greenish, dense, finely textured augite andesites occur in which none of the mineral constituents are megascopically discernible. These rocks closely resemble basalts both in appearance and composition, and frequently have prominent prismatic jointing (Plate XXIV). Rocks with a dense, aphanitic, reddish, greyish, or greenish, groundmass, in which well formed plagioclases are prominent are the commonest types. In places on Peninsula and Ear mountains flow-structures are well preserved.

Tuffs and breccias are of wide-spread occurrence and vary in texture from microscopic tuffs, to coarser rocks in which individual fragments several feet in diameter occur. These clastic rocks contain in places a considerable admixture of foreign materials and appear to pass gradually into the Laberge tuffs and greywackes.

In places the Chieftain Hill volcanics so closely resemble the andesitic members of the Perkins group that it is difficult to distinguish one from the other. The Perkins rocks are generally the more altered of the two, but in places there is not this distinction.

Microscopically the Chieftain Hill volcanics are seen to have a considerable range in structure and mineralogical composition, but consist chiefly of plagioclase, occasional orthoclase, hornblende, biotite, and diopside. The plagioclase is the chief component of these rocks and occurs in both generations. The plagioclase phenocrysts range from andesine to bytownite, and are generally well formed and twinned according to the albite and frequently the Carlsbad and pericline laws as well; zonal structures are also plentiful. An acid plagioclase is always present in the groundmass and is prevailingly andesine, but oligoclase as well as more basic varieties also occur. Orthoclase was noted in large well defined phen[illegible] and is frequently present in the groundmass. Microperthite also [illegible] but is not at all a characteristic constituent of these rocks.

Both common green hornblende and brown basaltic hornblende frequently occur, but of the two, the green variety is the more often encountered. They occur in both generations and may or may not be associated with biotite, but were nowhere seen in the same specimen with diopside. Brown biotite, which is probably quite as generally distributed in these rocks as the hornblende, is occasionally the only ferro-magnesian mineral present, and exists in both the first and second generations. The pyroxene present is always a colourless, or nearly colourless diopside, and although it forms quite distinct phenocrysts these are seldom of sufficient size to be seen with the naked eye. When present this is generally the only ferro-magnesian mineral in the rock, but brown biotite occasionally accompanies it. As accessories, magnetite is always present, and frequently occurs peppered all through the groundmass. Pyrite is also at times abundant, but is not as universally present as the magnetite. Zircon and apatite are also common accessory minerals.

The minerals are frequently much altered, and the plagioclase, hornblende, and diopside are always to some degree affected. The plagioclase is changed mainly to calcite and epidote, and in some cases is almost entirely replaced by these minerals. The hornblende alters mainly either to chlorite and epidote, or chlorite, calcite, and quartz. The diopside is transformed chiefly to chlorite.

These rocks are always distinctly porphyritic in structure and the phenocrysts are generally fairly abundant, so the fabric might be described as prevailingly dopatic to sempatic.[1] The groundmass varies considerably and ranges from hypohyaline or partly glassy to holocrystalline, but is rarely coarser than microcrystalline. Pilotaxitic structures are very characteristic of the groundmass, and in such cases, the feldspars have somewhat the appearance of a number of small sheepegs irregularly distributed and filled in between with chiefly single prismoids, and iron ore grains. In places a certain amount of brownish glass is also present and in such cases, the structures are referred to as hyalopilitic. In a few places, andesites also occur having a micrographic groundmass which consists chiefly of plagioclase, orthoclase, quartz, and biotite.

The tuffs and breccias at times contain considerable sedimentary material, but generally consist chiefly of andesitic particles embedded in a finely textured, often dense and partly glassy, groundmass.

AGE AND CORRELATION.

These volcanics, for the greater part at least, appear to be more recent than the Jura-Cretaceous sediments, but in places the tuffs and greywackes of the Laberge series pass gradually into Chieftain Hill tuffs and breccias, showing that the andesitic period of vulcanism commenced during Jura-Cretaceous sedimentation. Also, some of the volcanics, those forming the top of Gleaner mountain for instance, appear to be extrusive over the Laberge beds rather than intrusive in them.

The andesitic rocks are cut by the Carmack basalts, and the Wheaton River volcanics, and so are older than these.

The name Chieftain Hill volcanics was first applied in Wheaton district where these rocks are extensively developed. They

[1] Cross, Iddings, Pirsson, and Washington, "The texture of igneous rocks," Jour. of Geol., Vol. XIV, No. 8, Nov.-Dec., 1906.

Plate XXIV

[illegible]

28627 -p 66

[illegible] also to the [illegible] of different portions of [illegible] described by [illegible] and Mr. Leach.[2]

Klusha Intrusives

[illegible]

Klusha intrusives [illegible] less than 50 feet in thickness [illegible] 200 to 300 feet in diameter, occur respectively on Armstrong [illegible] and on the hills [illegible] particularly plentiful in [illegible] nearly all portions of the district.

[illegible]

The Klusha intrusives [illegible] granite-porphyries [illegible] light grey [illegible] granular [illegible] the principal mineral components are discernible [illegible] eye.

[illegible] these rocks [illegible] phyritic structure, and to consist of a micrographic [illegible] quartz-feldspar groundmass, in which alkali feldspar and lime [illegible] spar phenocrysts are plentiful, and in which biotite and [illegible] monly occur.

The feldspars are mainly orthoclase and microcline [illegible] about equal amounts, and are in most cases only slightly altered [illegible] certain amount of transformation to muscovite and [illegible] has generally occurred. In addition to these alkali feldspars, [illegible] amounts of an acid plagioclase are always present [illegible] as large, well-formed phenocrysts which are much altered [illegible] epidote, calcite, and quartz, and also to a less degree to muscovite. Brown biotite also frequently occurs in both generations, and [illegible] changed to chlorite. Common green hornblende [illegible] magnesian mineral that has been found in these rocks [illegible] than the biotite and alters [illegible] to chlorite [illegible] Accessory apatite and zircon are [illegible] present [illegible] either hornblende [illegible]

The groundmass is generally micrographic [illegible] exhibit micropegmatitic quartz-feldspar intergrowth [illegible]

[1] Dawson, G. M., Rep. of Prog., Geol. Surv. Can., 1875-77 [illegible]
[2] Leach, W. W., "The Telkwa river and vicinity, B.C." Geol. Surv. Can., 1907, pp. 10, 11.
Leach, W. W., Sum. Reports, Geol. Surv., Dept. of Mines, Can. [illegible] 20, 1908, p. 4.

A typical specimen from a dyke on the south side of Graham inlet was analysed by the Mines Branch of the Department of Mines, showing the rock to be composed of the following:—

SiO_2	[illegible]
Al_2O_3	[illegible]
Fe_2O_3	[illegible]
FeO	[illegible]
MgO	[illegible]
MnO	[illegible]
CaO	[illegible]
Na_2O	[illegible]
K_2O	[illegible]
H_2O at 110°C	0.09
H_2O above 110°C	[illegible]
TiO_2	[illegible]
P_2O_5	0.06

The specific gravity = [illegible]

AGE AND CORRELATION.

The Klusha intrusives are very recent and, with the exception of the unconsolidated Quaternary deposits, may be the newest rocks in the district. Whether they are older or newer than the Carmack basalts is not known. They are, however, closely related to the Wheaton River volcanics, differing from them chiefly in texture. It is thought, therefore, that both the Klusha intrusives and the Wheaton River volcanics may belong to the same period of igneous activity; if so, the Klusha rocks are more recent than the basalts.

The name Klusha intrusives was first employed in Braeburn-Kynocks coal area, to represent a series of syenite-porphyries that much resemble the syenite- and granite-porphyries in other portions of Yukon and northern British Columbia. Similar rocks have been described in the writer's report on a 'Portion of Conrad and Whitehorse mining districts,' under the name 'granite-porphyry,' and in that district were found to pass from granite- to syenite-porphyries without any marked difference in their general appearance. The Klusha intrusives are also described in the writer's report on Wheaton district.

Carmack Basalts.

DISTRIBUTION.

Carmack basalts were noted in Taku Arm belt in only two localities, the more southerly of which is situated on the west shore of Taku arm south of Fantail river. There these rocks are apparently developed over an area which extends about one-half mile along the shore and reaches westward from the water's edge about one-fourth to one-half mile. The other locality is on the southwest corner of Armstrong peak, where Carmack basalts outcrop over an area about 1,000 feet in diameter.

LITHOLOGICAL CHARACTERS.

The Carmack basalts are greenish to reddish-brown rocks with an aphanitic groundmass through which distinct phenocrysts, mainly of olivine, and augite, can often be detected with the unaided eye, and are, in places, sufficiently large and abundant to give the basalts a medium textured, granular, appearance. In places the representatives of these rocks are mainly tuffs and breccias, the fragments varying in size from microscopic to 1 or 2 feet in diameter. In the vicinity of Kirtland, just south of the mouth of Fantail river, the basaltic rocks are predominantly tuffs and breccias.

Microscopically these rocks are seen to be typically porphyritic in structure and to consist largely of plagioclase, augite, and olivine, with occasionally considerable accessory iron ore. The plagioclase occurs in both generations, the phenocrysts being prevailingly diverse-tabular in form and embedded in a groundmass composed mainly of plagioclase, augite, and olivine, with their alteration products. The augite phenocrysts are large, idiomorphic, and generally but slightly altered. The olivine is partly, and in places entirely replaced mainly by serpentine, but also to some extent by calcite and iron. The olivine and augite phenocrysts are prevailingly much larger in size than the feldspars.

AGE AND CORRELATION.

No evidence is obtainable in Taku Arm belt concerning the age of the Carmack basalts, except that they pierce Carboniferous limestones. In Wheaton district, however, they intersect the Chieftain Hill volcanics and are in turn cut by the Wheaton River volcanics. They have been described in the writer's report on 'Lewes and Nordenskiöld Rivers coal district' where the name Carmack basalts was first applied, and also in the report 'On a portion of Conrad and Whitehorse mining districts' under the term 'scoria and basalt.' McConnell has also described these rocks in Whitehorse district, under the name 'basalt.' In all the districts the basalts are seen to be pre-glacial, but to have flowed into, or been deposited in the valleys after these had been eroded to almost their present form. The Carmack basalts thus appear to be of late Tertiary or Pleistocene age.

Wheaton River Volcanics.

DISTRIBUTION.

Wheaton River volcanics occur in Taku Arm belt mainly as occasional dykes prevailingly 10 to 20 feet in thickness. Several of these dykes were noted on the eastern portion of Taku mountains, and one development approximately 500 feet wide at the widest point, and 3,000 feet long, occurs on the north side of Racine creek about one half mile from Taku arm.

LITHOLOGICAL CHARACTERS.

The Wheaton River volcanics in Taku Arm belt are mainly rhyolites in which white to light grey colours prevail. In places, however, they contain pyrite which oxidizes, giving them a bright red to brownish or yellowish red colour. These rocks have characteristically a felsophyric groundmass in which phenocrysts of quartz, orthoclase, and occasionally plagioclase occur. The quartz occurs frequently in distinct dihexihedrons which are as much as [illegible] of an inch in diameter. Well formed megaphenocrysts of orthoclase and plagioclase also occur, but those of the alkali feldspar are much the more plentiful. The rocks when considered as to their relative amounts of phenocrysts and groundmass might be described as varying from perpatic or those extremely rich in groundmass, to dopatic, in which the groundmass is dominant.

Macroscopically the rhyolites are se[illegible]ays have a porphyritic structure, the phenocrysts being predom[illegible]gascopic and consisting of quartz and alkali and lime-alkali felds[illegible]hoclase is considerably the most abundant mineral of the first g[illegible]on and occurs in large idiomorphic forms which often exhibit Carlsbad twinning and are frequently much altered to muscovite. Quartz exists mainly in 6-sided an[illegible] 4-sided forms which are often considerably corroded. Large acid plagioclase individuals are occasionally present and are generally much altered to kaolin and quartz. Accessory iron ores are also commonly present and apatite and zircon occur.

The groundmass is generally holocrystalline, although in some instances it is hypohyaline and might then be described as ranging from percrystalline (extremely crystalline with some glass) to docrystalline (dominantly crystalline). The fabric of the groundmass is characteristically micropegmatitic, and beautiful intergrowths of quartz and feldspar are seen, representing the crystallization of eutectic mixtures of these minerals. Micrographitic fabrics also occur, but are less common than the micropegmatitic. In such cases the groundmass is holocrystalline granular, and consists chiefly of quartz and alkali feldspar.

AGE AND CORRELATION.

The Wheaton River volcanics are the most recent, consolidated rocks in the district, except possibly the Klusha intrusives. No evidence has been obtained to show [illegible] but since they are of almost identical chemical and mineralogical composition, and differ chiefly in texture, it is most probable that they are nearly, if not quite synchronous.

The name Wheaton River volcanics was first applied in Wheaton district where these rocks are seen to be unquestionably pre-glacial, but to have come into the valleys of the district after these had been incised to almost their present depth. These volcanics are thus of late Tertiary or Pleistocene age.

Quaternary.

DISTRIBUTION.

All the main valleys of the district are floored with Quaternary deposits which in places are of considerable thickness, sufficiently thick in fact to cause reversed slopes, impounding great quantities of water. All the lakes of the district, including Lake Atlin, are held in position by dams of this kind. These deposits occur nearly everywhere in the lowlands or flats, along the sides of the lakes, and in places appear to be 100 feet or more in thickness, though bed rock frequently out-crops through them. The Pleistocene materials extend well up the valley walls, and in places reach nearly or quite to the plateau surface. The terraces noted near the mouth of Tut-shi river and elsewhere, appear to be composed entirely of Pleistocene deposits. A thin mantle of Recent materials covers the surface of the district nearly everywhere except on steep slopes and escarpments.

LITHOLOGICAL CHARACTERS.

The Pleistocene and Recent terranes of the district are lithologically very similar, and grade into each other to such an extent that it is, in places, difficult to distinguish them.

The Pleistocene deposits consist chiefly of gravels, sands, silts, and boulder-clays, and as these have been only slightly dissected in most places, cross-sections of them are almost lacking; generally only the surfaces of these materials are to be seen, but little erosion having occurred since Pleistocene times. In places, however, it could be seen that the deposits of unsorted morainal materials and boulder-clays, as well as sands and silts deposited in streams and lakes, were of considerable thickness.

The Recent deposits are composed of glacial, fluvial, and littoral, silts, sands, and gravels produced by the present streams and glaciers, as well as ground ice, peat, muck, and soil. The sands, gravels, and silts are exposed along the present streams and lakes, and ground ice is in many places persistently present a few inches or a few feet beneath the surface. Peat and muck occur mainly in the wide flats and around the lakes, which lie in poorly drained portions of the valleys and hence are favourable localities for such accumulations. The glacial silts, such as those which are at present being deposited in the flats at the head of Taku arm, are quite similar to the Pleistocene silts; and the other Recent glacial materials forming along the edge of the Coast range are lithologically almost identical with the deposits formed in the early Quaternary. A thin layer of soil constitutes the uppermost deposit in the valleys, on the upland, and, in places, on the valley walls and mountain slopes.

ECONOMIC GEOLOGY.

GENERAL.

Placer gold was first mined on the Atlin creeks early in the year 1898, and since that time this industry has been the mainstay of the town and surrounding district. During these years a certain amount of attention has also been paid to various quartz discoveries, and recently those interested in the welfare of the camp have begun to hope that this class of properties may continue to produce after the gravels have become exhausted, and so prolong the life of Atlin as a mining district. Although a complete discussion of the economic geology of Atlin district would primarily treat of the placer-deposits, for the reasons given in the introductory paragraphs of this report, this chapter will deal only with the non-placer mineral occurrences, including the ore deposits and coal not only of the Taku Arm belt that was surveyed during 1910, but of Atlin district generally.

For convenience of description, the non-placer mineral deposits may be classified as follows:—

Ore Deposits

(*a*) Gold-tellurium quartz veins.
(*b*) Gold-silver quartz veins.
(*c*) Cupriferous silver-gold veins.
(*d*) Silver-lead veins.
(*e*) Copper veins.
(*f*) Antimony veins.
(*g*) Contact metamorphic deposits.

Coal

Gold-tellurium veins have been found only at the Engineer mines and on adjoining claims which are situated on the west side of Taku arm above Golden Gate, and much the richest ore discovered in Atlin district has been obtained from these properties. The finding at the Engineer mines of pockets of quartz worth from $3 to $5 per pound, caused considerable excitement during the summer of 1910, and has had a decided effect in arousing enthusiasm in quartz mining. The gold-silver veins are the most wide-spread type of deposits, and are found in a number of localities distributed over the greater part of the district. Cupriferous silver-gold veins have been found on Table mountain, where, however, only one deposit of any promise has been discovered. A number of strong, well-mineralized veins, belonging to the silver-lead division, occur on Crater creek and in that vicinity. Copper veins have been found on the southern end of Copper island, but those so far discovered do not appear to be of present economic importance. One antimony vein is known to occur in the district; it outcrops on the west shore of Taku arm 10 miles below Golden Gate, but as the deposit has been exposed for only about 15 feet, very little is known concerning it. Contact-metamorphic deposits, so far as is known, occur only on Hoboe creek near the upper end of Torres channel. These possibly should all be considered as belonging to a single ore body since they are situated along the same geological contact, and it seems probable that the ore persists between the points where it outcrops or has been encountered. The ore-material consists largely of magnetite carrying varying amounts of copper, and wherever it has been exposed exceeds 30 feet, and is at one point 150 feet in thickness. Outcrops have been discovered throughout a distance of at least 3,000 feet.

No coal seams have been found in the area, but the Tantalus conglomerate, which is always associated with coals in southern Yukon, occurs at several points. Also a considerable amount of float coal has been found to the northeast of the lower end of Sloko lake, and there is every likelihood that the seams from which this is derived will yet be found.

ORE DEPOSITS.

Gold-Tellurium Veins.

GENERAL.

Gold-tellurium quartz veins have been discovered in Atlin district in only one locality which is situated on the east side of Taku arm above Golden Gate. The greater number of the veins occur at the Engineer mines where the bulk of the rich ore in this type of deposits have been found. Veins containing pockets of good ore, however, have also been discovered on adjoining claims.

THE ENGINEER MINES.[1]

General. This property is situated on the east side of Taku arm about 10 miles above Golden Gate (Diag. 5), and consists of eight connected claims, four of which extend to the water's edge, the other four adjoining these to the east. The group is owned by the Northern Partnership composed of Captain James Alexander, John Dunham, B.G. Nied, and K. Wawrecka.

The Engineer mines were first located in 1899, and a joint stock company was formed, known as the Engineer Mining Co., who held the property until 1906. The claims are then believed to have lapsed, and were located by Edwin Brown and partners who held the property one year, when it was acquired by the present owners.

[1] The report of the Minister of Mines of British Columbia, for each year, contains the report of the Gold Commissioner of Atlin district, in which information is given concerning the development, etc., of the various quartz claims in the district. As these descriptions are generally very brief they are not referred to in the lists of references given under each property.

[2] Robertson, W. F. (Provincial Mineralogist), Report of the Minister of Mines, B.C., 1900, pp. 760-762; 1901, pp. G 80-G 81.

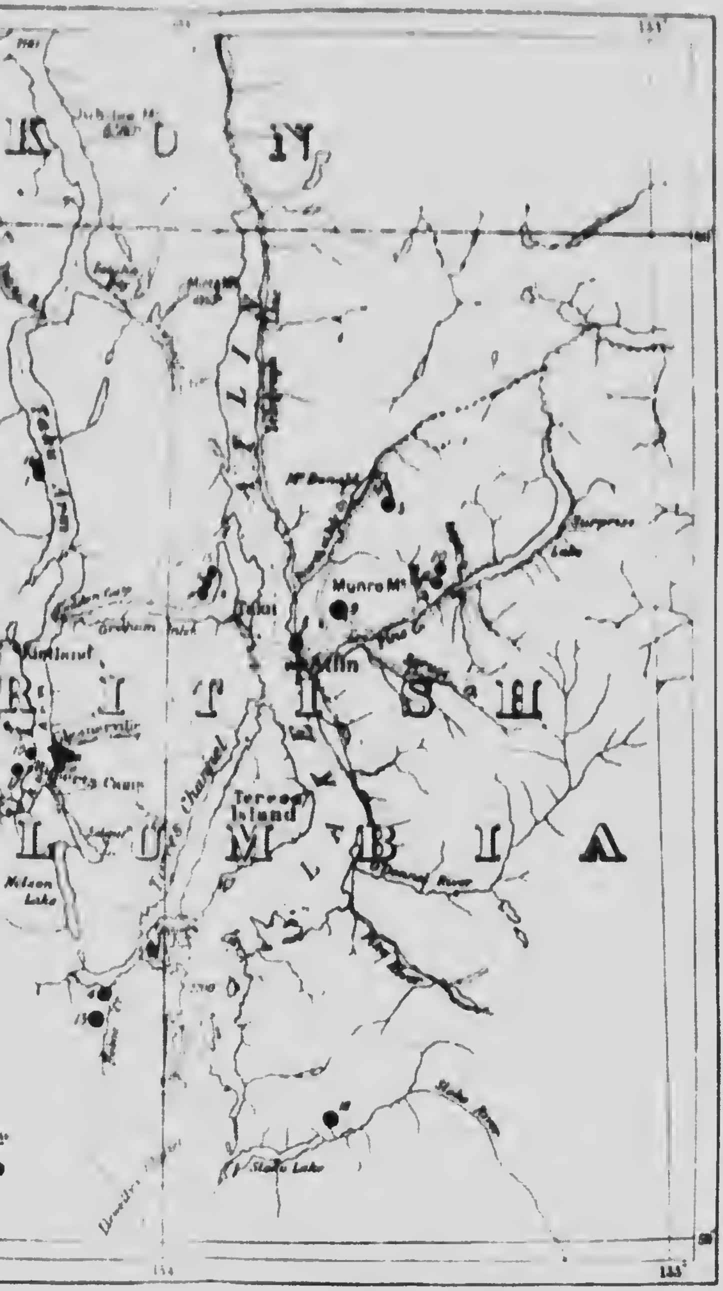
Gwillim, J. C., "Report on the Atlin mining district, British Columbia," Geol. Surv., Can., Ann. Rep., 1899, Vol. XII, p. 45B.

Cairnes, D. D., "Canadian tellurium-containing ores," Jour. Can. Min. Inst., 1911, pp. 91-99.

Plate XXV.

28627—p. 74.

Diag. 3. Mineral locations in Atl



MINERAL LOCATIONS

1 Antimony Claim
2 Beavis Mine
3 Big Canyon Group
4 Calahan Group
5 Copper Vane
6 Dunder Group
7 Engineer Mines
8 Glacier Group
9 Imperial Mines
10 Kirtland Group
11 Lakefront Claim
12 Lake View Group
13 Laverdière Group
14 Lawson Group
15 Pelton Group
16 Patty Group
17 Rupert Group
18 Slaka Lake Coal Cla
19 Whitemoose Group
20 White Star Group

Placer Claims are not indic

ons in Atling mining district, B.C.

[illegible] minerals or [illegible] [illegible] they were from [illegible] [illegible] The vein [illegible] [illegible] composed [illegible] [illegible] [illegible] and inter[illegible] [illegible] The metallic minerals [illegible] gold [illegible] [illegible] of [illegible] as well as [illegible] [illegible] veins are those of value only for their gold [illegible]

It is not known even approximately [illegible] gold the larger veins contain, but [illegible] results ranging from traces to about $[illegible] per ton. [illegible] remarkably rich [illegible] [illegible] that [illegible] thickness [illegible] have been [illegible] prospected and developed.

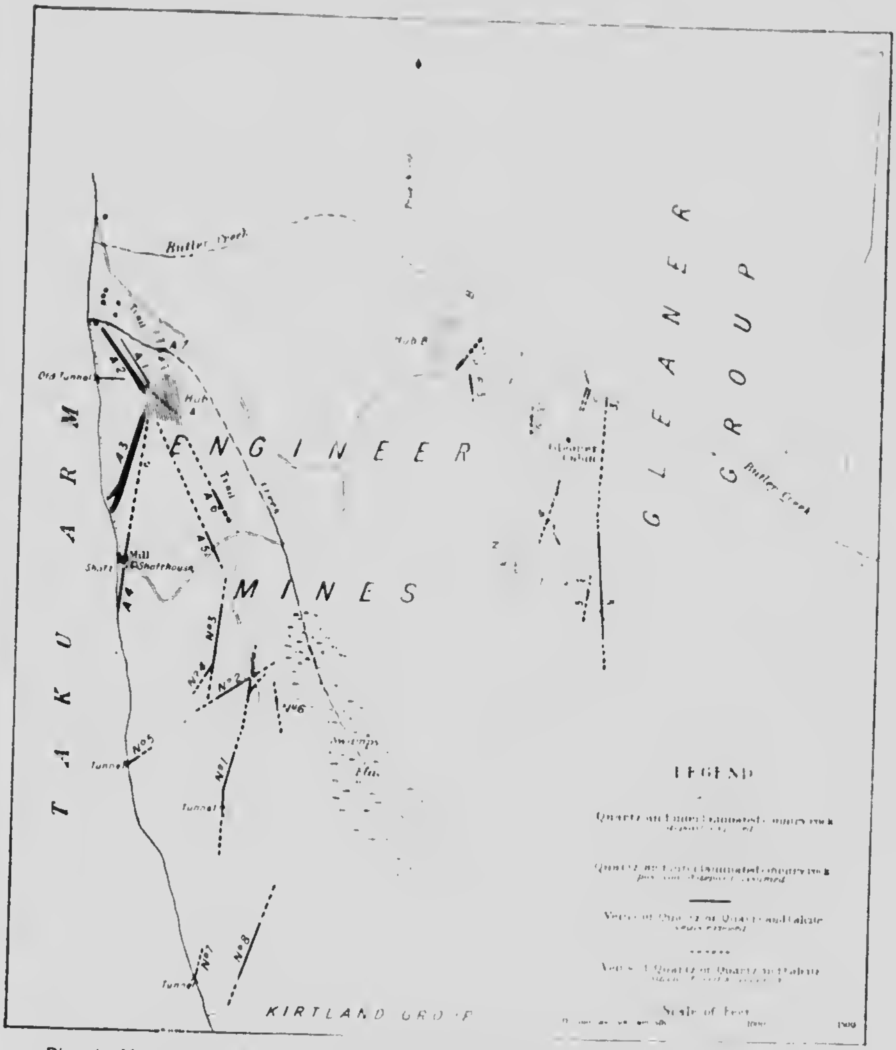
This group of claims [illegible] [illegible] [illegible] [illegible], and [illegible] direct [illegible] with [illegible] the White Pass and Yukon [illegible] The property is still in the uncertain prospect [illegible] [illegible] features.

Geological Formations.—The geological formations [illegible] the vicinity of the [illegible] veins are predominantly [illegible] finely textured greywackes, shales, and slates, of the [illegible] series, which range from brownish and dark greenish to almost black in colour and are probably to a considerable extent pyroclastic in nature. These beds have been invaded by dykes of [illegible] granite porphyry, and are, in places, faulted, folded, and considerably distorted, but have a general strike about N. [illegible] W. and dip to the northeast, at an average angle of about [illegible] Most [illegible] occur in the dark to almost black, finely textured, Laberge members.

General Characteristics of the Veins.—Two large, central, compound veins or lodes consisting of quartz and intercalated and brecciated shale, slate, and altered rocks occur, from which several veins radiate, most of them in northwesterly and southeasterly directions. In addition, a number of veins have been discovered which are not, as yet, [illegible] [illegible] central quartz area.

Hub A (Diag. 4) is at least 200 feet wide at its widest point, and is over 300 feet in length, but owing to a covering of superficial materials neither the entire length nor width of the vein was ascertained. The mass consists largely of quartz, but also contains a large proportion of intercalated bands of shale and slate. In places, bands of shale 1 to 2 inches thick alternate with stringers of quartz of similar thickness. At other points the rock has been much brecciated, and the particles have been cemented together mainly with quartz and calcite. The relative amounts of secondary minerals and original rock vary greatly, so that in some places there is a predominance of rock, and in others, the vein consists almost entirely of quartz and calcite.

Three veins, A 1, A 2, and A 3, have been definitely traced to a junction with hub A. In addition, A 4, A 5, and A 6 strike toward the hub, and although, owing to superficial covering, they could not be followed to the central area, their strike indicates that they join it. The strike and form of the quartz of the northern end of hub A, also indicate the presence of a wide vein as indicated by A 7, but this is not exposed.



Diag. 4. Map showing the vein outcrops on the Engineer mines property, and on the Gleaner group, Atlin mining district, B.C.

Hub B is very similar in appearance to hub A, contains a large amount of intercalated and brecciated shale and slate, and is in reality a compound vein. It is at least 270 feet wide, as this much is exposed to view, but neither wall was found. Toward the edges of the vein, the proportion of rock gradually increases, and probably continues to increase, producing walls of an indefinite character.

The following tables give the main characteristics of all the veins except the two hubs which have just been described.

Vein	Strike.	Dip.	Thickness.	Distance traced	Remarks
A 1	N. 68° W.	80° to N.E.	6 to 10 feet	300 feet	Consists mainly of quartz
A 2	N. 70° W.	Apparently nearly vertical.	20 to 30 feet.	400 feet	Consists mainly of quartz.
A 3	N. 48° W.	Nearly vertical.	Average of 30 feet.	350 feet	Toward southern end and near the shore, the vein splits up into several veins 6 inches to 2 feet in thickness. Vein includes considerable intercalated shale, in places up to 20 p.c. of its volume; the remainder of vein is mainly quartz.
A 4	N. 50° W.	70° to 80° to S.E.	2 to 3 feet.	250 feet.	Consists mainly of quartz.
A 5	N. 64° W.	80° to N.E.	2 to 10 inches	300 feet.	Consists mainly of quartz
A 6	N. 64° W.	75° to 80° to N.E.	4 to 20 feet	200 feet	Where thin, vein consists mainly of quartz, but in thickest portions includes up to 30 p.c. of intercalated shale layers. Vein to a considerable extent lies conformable to bedding planes of formation, and so differs from the majority of the veins.

B 1.	N. 20° W.	[illegible]	[illegible] feet	40 feet	Contains [illegible] 30 per cent [illegible] 40 per cent brecciated and [illegible] rock.
B 2.	N. 5° E.	Vertical (?)	10 to 12 feet	40 feet	Consists mainly of quartz.
B 3.	N. 64° W.	[illegible]	3 to 4 feet	100 feet	Consists mainly of quartz.
No. 1.	N. 21° W.	50° to 60° N.E.	6 inches to 3 feet.	600 feet	Consists mainly of quartz.
No. 2.	N. 23° E.	Nearly vertical in most places.	2 to 12 inches	200 feet	Consists mainly of quartz.
No. 3.	N. 28° W.	Approx. 70° to N.E.	4 to 10 inches, in most places 4 to 6 inches	150 feet	Consists mainly of quartz. Intersects No. 4 vein and persists through it.
No. 4.	N. 1° E.	80° to S.E.	2 to 6 inches	50 feet . . .	Consists mainly of quartz.
No. 5.	N. 24° E.	Nearly vertical.	6 to 14 inches	30 feet	Consists mainly of quartz. Thought by owners to be, and probably is, the southwest extension of vein No. 2, but between the most southwestern known portion of No. 2 and the nearest exposed part of No. 5 is a distance of over 400 feet, so the correlation is uncertain; however, the dips, strikes, and character of the outcrops are similar.
No. 6.	N. 24° W.	70° to S.E.	6 to 18 inches	50 feet . .	Consists mainly of quartz.
No. 7.	N. 20° W. approximately.	Nearly vertical.	4 to 16 inches	50 feet . . .	Consists mainly of calcite and quartz; the calcite predominating.

No. 8.	N. 13 W	80° to S.W.	10 to 15 feet.	300 feet.	Brecciated vein composed almost entirely of broken and comminuted portions of shale and slate cemented together chiefly by quartz and also to some extent by calcite. The proportion of the gangue minerals in the vein varies from possibly 75 p.c. or 80 p.c. to less than 50 p.c
No. 9.	Apparently N. 56° W.	?	50 feet	150 feet.	Strike indicates that it joins hub B, which it much resembles in character, being a typical brecciated vein.
No. 10.	N. 47 W.	?	Approximately 4 feet.	75 feet.	Consists mainly of quartz and varying amounts of intercalated shale and altered rock.

All bearings in this report, unless otherwise mentioned, are magnetic. The magnetic variation in this district is about 33°E.

Mineralization of the Veins.—The gangue and ore minerals of these veins consist mainly of quartz, calcite, native gold, one or more telluride minerals, pyrite, limonite, and native antimony. The majority of the narrower veins are composed almost entirely of quartz with relatively small amounts of calcite; however, as mentioned above, the fissure-filling of No. 7 vein consists predominately of calcite. A number of the veins, particularly the hubs and wider veins, contain in addition to these two gangue minerals, much intercalated and brecciated shale and related materials, and also a greenish chloritic mineral which appears to result from the alteration of the wall-rocks.

The quartz is characteristically well crystallized, and long delicate prisms are very common; these occur in parallel bands with the familiar comb-structures, or radiate from some central particle or mass of rock or ore. In the inter-crystal spaces, that thus result, the metallic minerals have largely been deposited. Dense, massive quartz occurs in places, mainly in the larger veins, but even there, vugs lined with quartz crystals are of frequent occurrence. In many cases the walls of the various small cavities in the veins are lined with calcite crystals.

Native gold is the most common metallic mineral in the veins, and is in places plentifully distributed through pockets or shoots of ore, either in fine grains or thin scales which gradually merge into leaves a half an inch across. Associated with the gold are occasional minute and imperfect prismatic forms of a brass-yellow telluride the principal base of which is gold; this telluride is probably mainly calaverite. A few specimens of native antimony were also found. Occasional particles of pyrite and its oxidation product, limonite, also occur in some of the veins.

Development Work.—The original Engineer Mining Company ran a cross-cut tunnel about 300 feet long from the water's edge to tap hub A, but instead of intersecting this quartz body, the tunnel cross-cut vein A 2, and did not reach the larger deposit; about 100 feet of drifts and cross-cuts were driven from this tunnel. The Company also sank a shaft about 20 feet deep on vein A 4, near the point where it comes to the shore of Taku arm; they also sank a compartment shaft that was intended to tap vein A 4, just back of the present mill; this shaft was filled with water when visited by the writer, but is said to be about 70 feet deep. In addition, a few small surface cuttings were made by this Company.

The Northern Partnership deepened the 20 foot shaft on vein A 4, but had to cease operations until winter on account of too much water. Two tunnels were commenced on veins No. 5 and No. 7 from the water's edge, and were driven about 10 feet; a tunnel was started on vein No. 1 (Diag. 4), and was run about 30 feet. Vein No. 1 has been followed almost continuously for 600 feet by trenching from 6 inches to 6 feet deep. A trench 1 to 7 feet deep has also been dug along the outcrop of vein No. 2 for about 200 feet. In addition, a few shallow trenches and open-cuts have been made in hub A and hub B, and on veins A 5, A 6, B 3, No. 3, No. 4, No. 6, and No. 8. This constitutes practically all the development work that has been so far performed on the Engineer mines property. During the past season the work performed by the Northern Partnership was practically all done on the surface, with the object of determining as far as possible the number of veins and the portions of them that contain ore immediately available for milling. This surface prospecting and development was carefully, although necessarily slowly conducted, and has given very satisfactory results.

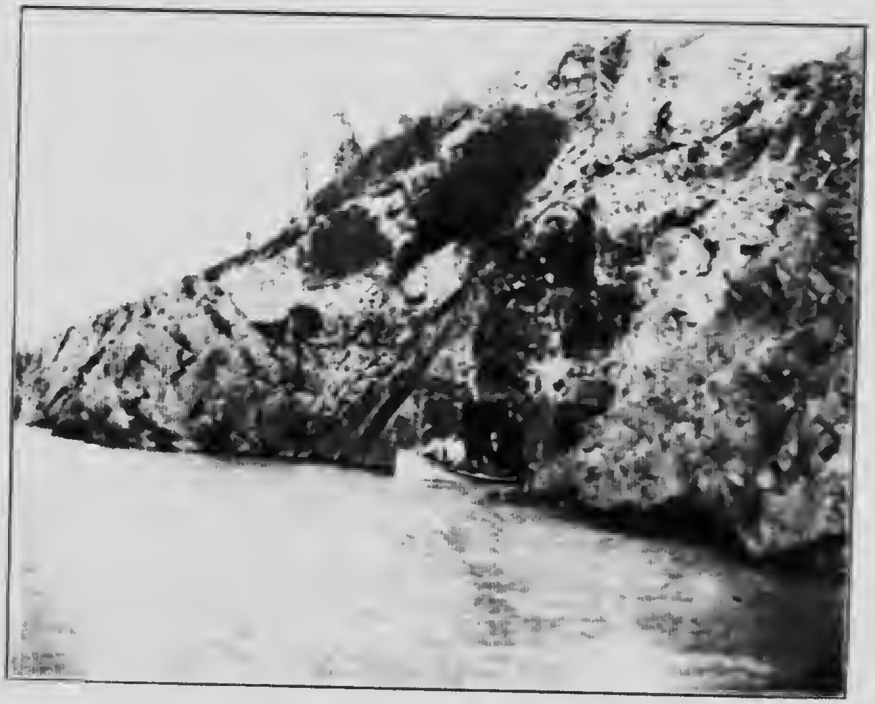
A 2-stamp Joshua Hendry mill, the construction of which was commenced several years ago, was completed early in the season and was in operation during part of the summer.

Values.—Few assays have been made by the Northern Partnership of the ores on their property; instead, the owners have depended almost entirely for guidance in development upon the presence or absence of visible gold, with the result that no reliable estimate can be formed as to the probable amount of gold that the bulbs and larger veins contain. Minute specks of native gold, however, are to be seen in all the larger deposits, and the few assays that have been made gave results ranging in most cases, from traces to about ten dollars per ton. Very rich ore occurs in pockets or shoots in a number of narrower veins, the best being obtained from veins No. 1, No. 2, No. 5, No. 7, and A 4; in addition, a number of sacks of good ore were taken from No. 3, No. 6, A 5, and A 6.

The pockets appear to occur mostly at points where the veins are intersected by cross-fissures; they also vary considerably in size, some holding only a portion of a sack while others contain several sacks. The greater part of this pocket-ore has a value of from $1 to $5 per pound. The only body of rich ore of sufficient size to be termed a shoot, that has so far been explored, is in vein No. 1; this has an average thickness of from 1 to 2 feet, is at least 20 to 30 feet in length, measured along the strike of the vein, and has been followed downwards for 30 feet without any apparent depreciation in values. This shoot might possibly better be described as a portion of the vein in which pockets are more common than is usual, but practically all the material so far obtained from it has been pay-ore.

The first 800 pounds of selected ore that was milled during this past season yielded 20 pounds 3 ounces (Troy) of gold and the next 1,000 pounds gave 20 pounds 8 ounces (Avoirdupois); in addition, the tailings in each case are claimed to contain approximately 30 per cent to 40 per cent of the original gold content, but this was not verified. The ore taken from the various prospecting trenches, open-cuts, short tunnels, etc., during the season up to September 1, was

Plate XXVI.



Entrance to the tunnel on vein No. 5 at the Engineer mines

28627—p. 82.

Plate XXVII.

[illegible]

Plate LXVIII

28627—p. 83

valued at about $25,000, and from the part of this that was milled, $8000 in gold bullion was obtained.

In addition to the high-grade pockets and shoots, much of the quartz between the pockets on veins No. 1, No. 2, No. 5, and No. 6 will probably pay to mill, and in some places it is claimed to run from $100 to $200 per ton, but in the opinion of the writer a fraction of the smaller of these amounts is a more probable average. The entire 4 feet of ore in the shaft on vein No. 6 is reported by the owners to average $200 per ton. Some very rich ore [illegible] have been obtained from No. 7, but the vein has not been explored for over 10 feet and not more than about a sack of the rich material has been obtained.

Oxidation and Enrichment.—These gold-tellurium ores are but slightly oxidized, largely because they contain practically no oxidizable minerals except occasional particles of iron which, near the surface, have been altered to limonite.

In gold-silver veins, of the calcite type in particular, it is common to find a decided enrichment in the oxidized part of the deposit, due to the reduction in volume of the ore by solution, and the removal of certain constituents, chiefly the soluble carbonates and sulphides. In the gold-tellurium veins under consideration, the gold to a great extent appears in arborescent forms and is largely definitely crystallized and so intimately intergrown with the quartz as to leave no doubt as to its primary origin in situ. Occasional particles have a brown tarnish and are slightly porous, and probably represent an oxidation product of the tellurides. There is, however, no evidence of any considerable surface enrichment, probably largely because the deposits contain little calcite and almost no sulphides, but even if these had existed the coldness of the waters in this northern latitude would very much retard chemical reaction or prevent its taking place.

Since the deposits have been so slightly altered at the surface, practically no zone of secondary enrichment is to be expected at the ground-water level. The veins, therefore, in all probability will continue for a considerable portion of their vertical extent to maintain almost the same characteristics and mineralization as at the surface; with greater depth, however, there is liable to be a slight increase in tellurides and a corresponding decrease in native gold.

Origin of the Veins.—Before the materials composing veins can be deposited, spaces must have been formed to contain them; a possible exception to this statement, however, exists in the case of veins produced by metasomatic replacement, where the solution of the original material and the deposition of the secondary vein matter are thought to occur simultaneously. In discussing the origin of the gold-tellurium veins at the Engineer mines,[1] the fissures or vein-containing cavities will be first considered and the fissure-fillings or veins will be treated later.

The Fissures.—The majority of the fissures, at least, have somewhat slickensided walls, showing that faulting has occurred, though, as an examination of the bedded wall-rocks shows, the displacements are generally slight, and often less than one foot. In only a few places has sufficient stripping and development work been done to enable the relative movement of the walls to be accurately measured, but in none of the cases where this was possible, did the displacement appear to be more than 10 feet.

Practically the only other characteristics these fissures possess that appear to assist in the investigation of their origin, are their dips and strikes. The dips are all highly inclined and where not coinciding with, or definitely influenced by that of the containing rocks, are nearly vertical. The strikes are the most peculiar and characteristic features of the fissures, in that they radiate outwards in various directions from certain central areas, or hubs. The bedding planes of the containing rocks have naturally greatly influenced the strikes, the greater number of which are northwesterly as the prevailing strike of the containing formation is N. 60° W. However, a glance at Fig. 2 will show that the fissures have a considerable range in strike, and the map of the veins at the Engineer mines (Diag. 4) shows the majority of the fissures radiating from two central hubs. Further investigations and development work may show that the remaining fissures also join some central quartz area.

A few of the veins, as No. A 4, have been deposited to a greater or less extent along the bedding planes of the enclosing clastic rocks, and in these cases the spaces between the strata have been sufficient to allow the veins to commence forming.

[1] This discussion applies also to the gold tellurium veins on the adjoining Gleaner and Kirtland groups.

The forces operative in the earth's crust that commonly produce fissuring are those of torsion, tension, and compression, all more or less aided by gravity. Daubreé[1] has demonstrated experimentally, that whenever torsional forces are effective, two systems of fracturing

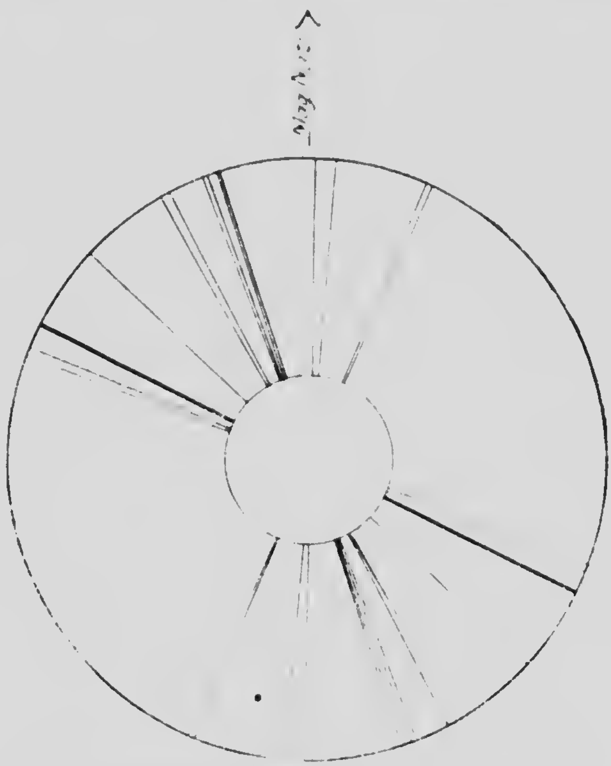


Fig. 2. Diagram showing the strikes of the veins at the Engineer mines, Atlin mining district, B.C.

tend to be produced, nearly at right angles to each other. Becker[2] and Van Hise[3] have also shown that compressive forces operative

[1] Daubreé, A., "Etudes Synthétiques de Géologie Expérimental," pp. 507-527.

[2] Becker, Geo. F., "Finite homogeneous strains, flow, and rupture of rocks," Geol. Soc. of Amer., Bull., Vol. IV, 1893, pp. 13-99.

[3] Van Hise, C. A., "Principles of Pre-Cambrian North American Geology, Sixteenth Ann. Rep., Pt. I, U.S. Geol. Surv., pp. 633-682.

in an approximately homogeneous substance, also give rise normally to two sets of fissures; these occur at about 45° to the direction of the applied force and, therefore, at about 90° to each other. Tensional forces tend always to produce a single set of parallel fissures. Fissures forming in the Laberge beds at or in the vicinity of the Engineer mines, would be greatly influenced by the bedding planes, but still, even taking these into account, none of the forces above enumerated seem to at all adequately account for these radiating ore-containing fissures, so a special explanation is required.

It is evident that if these rocks were subjected to an upward pressure from below, and this force were concentrated largely at certain points, that there would be a tendency for fissures to be formed radiating from these points; but as the resisting strength of

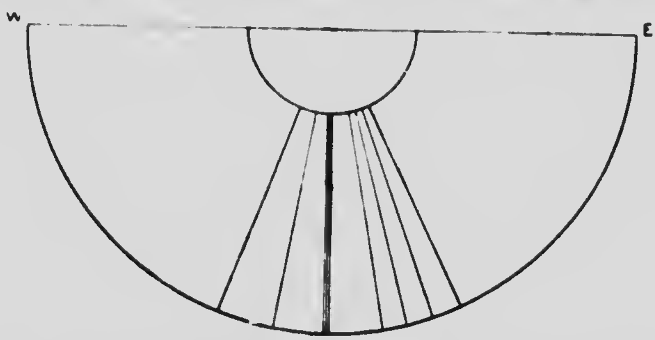


Fig. 3. Diagram showing the dips of the veins at the Engineer mines, Atlin mining district, B.C.

these beds is much less along their strike than at right angles to this direction, there would be a strong tendency for the fissures to have northerly strikes. This is what is seen at the Engineer mines, and the fissures there were apparently formed by such localized, upward-pressing forces. Only two probable causes suggest themselves to account for such phenomena.

The Engineer mines are situated near the eastern edge of the great Coast Range granitic batholith and dykes of related granite-porphyry have invaded the formation there. It is also quite probable that the formation at these mines is underlain by great masses of this granitic material; if this is so, it is possible that this intrusive body may have exerted the upward pressure required to form the fissures under consideration. On the other hand such an intrusive mass if exerting an upward pressure would probably do so not at a very limited number of points each only a few feet in diameter, but over considerable areas or along certain lines.

An alternative explanation for the origin of the fissures and one which seems more probable will now be given. According to this theory, the positions now occupied by the hubs were originally weak places in the formation which thus became readily fractured; and at these points the mineralizing solutions therefore found easy access and commenced depositing their quartz and other dissolved materials. It has been shown by Becker and Day[1] that the force exerted by a crystal while forming, is equal to that required to crush it when consolidated, and that many fissures have been considerably altered by the growing force of minerals being deposited in them. Accordingly as more and more quartz was deposited and continued to crystallize within these small fractured areas, a great and increasing pressure would be exerted, which would naturally find relief in sets of radiating fractures such as have been produced at the Engineer mines. This theory is further strengthened by the fact that the smaller veins consist almost entirely of quartz and related vein-materials, but the hubs and larger veins contain a great amount of brecciated and intercalated rock indicating the friable nature of the rocks there and the probability of its being much fractured and broken before the deposition of the quartz which consequently formed around and between the fragments. The widths of the hubs are thus probably largely conditioned by that of the friable zone of rocks which had probably been brecciated by the regional forces that caused the folding and tilting of the formation.

It is also probable that the force exerted by the growth of the quartz, has been an important factor in the formation of all the fissures, as once a small opening was produced sufficient for quartz-containing solutions to enter and deposit even a small amount of their burden, it is thought that the force of crystallization would be sufficient to gradually force the walls apart to make room for itself and additional solution.

[1] Becker, Geo. F., and Day, Arthur E., "The linear force of growing crystals," Wash. Acad. of Sci., Proc., Vol. 7, pp. 283-288, 1905.

Metasomatic replacement has been also a factor here in the production of these veins, but does not appear to have been at all extensive.

The Fissure fillings. A study of ore deposits shows, in general, that they are divisible into the following zones:—

Zone	Class
(1.) Oxidized zone.	Secondary.
(2.) Secondary enrichment zone.	Secondary.
(3.) Upper vein zone.	Primary.
(4.) Deeper vein zone.	Primary.
(5.) Pneumatolytic zone.	Primary.
(6.) Magmatic zone—ore solidified from fusing.	Primary.

In any particular deposit, however, one or more of these zones may be missing, or the entire deposit may belong to one zone. During recent years, a number of geologists have studied the various vein-forming minerals with a view to determining their mode of occurrence and origin, and have discovered that certain mineral combinations are characteristic of each of these vein zones.[1] Also certain individual minerals are diagnostic of particular zones, but as such minerals are prevailingly of rare occurrence, the mineral combinations are the more useful in considering the genesis of an ore deposit.

These gold-tellurium ores are only slightly oxidized, and, as explained previously, are largely at least primary; they are also decidedly not of the magmatic zone; so must belong to divisions 3, 4, or 5. Further, none of the minerals are found that are characteristic of the deeper vein zone, such as albite, amphibole, biotite, diopside, garnet, hornblende, scapolite, spinel, topaz, graphite, ilmenite, pyrrhotite, specularite, etc., and there is a decided lack of the minerals characteristic of pneumatolytic veins, i.e., those that are now recognized to be directly connected with plutonic intrusion rocks and have been derived from these through the agency of magmatic gases dissolved in them at the time of their intrusion, and existing, therefore, at high pressure and above the critical temperature of

[1] Lindgren, Waldemar, "The relation of ore-deposition to physical conditions," Econ. Geol., Vol. II, No. 2, pp. 105-128.
Emmons, W. H., "A genetic classification of minerals," Econ. Geol., Vol. III, No. 7, pp. 611-627.

water. Some of the minerals most valuable in determining deposits belonging to the pneumatolytic zone are tourmaline, fluorite, apatite, spodumene, muscovite, alkali feldspars, cassiterite, wolframite, molybdenite, magnetite, bornite, and arsenopyrite.

It follows by a process of elimination that these gold-tellurium veins belong to the upper vein zone. Moreover the minerals composing the deposits are mainly quartz, calcite, native gold, tellurides, and pyrite. Of these the quartz, pyrite, and native gold are known to frequent deposits of all zones and so, by themselves, afford little information. The calcite is also somewhat persistent, but tellurides are only known in the deeper vein, and upper vein zones. It is thus apparent that these deposits belong to the upper vein zone, as they possess a mineral combination characteristic of it, and have none of the peculiarities of the other zones.

That ore-bearing quartz veins are deposited from circulating waters containing dissolved gases and metalliferous compounds, is a now well recognized fact. It is further generally supposed that these waters are associated with the intrusion of igneous rock. In the case of these gold-tellurium veins, granite-porphyry dykes occur in the vicinity and the veins are located near the eastern edge of the Coast Range granitic batholith to which the dykes are related. It would thus appear quite probable that the veins are genetically associated with these granitic rocks and that the materials composing them were deposited from solutions derived from the granitic magma.

THE GLEANER GROUP.[1]

General.—The Gleaner group consists of three claims and a fraction that lie to the east of and adjoin the Engineer mines (Diag. 3). These claims were located in 1900, and in 1901 the owners formed a joint stock company, known as the Gleaner Mining and Milling Company, who still hold this property. This Company is capitalized for $250,000, the president is Mr. David Stevens, the secretary-treasurer is Mr. P. F. Scharschmidt of Whitehorse, Y.T., and the board of directors include the above named officers and Mr. R. Butler of Atlin, B.C., Dr. Lindsay of Calgary, Mr. D. Von Cramer of Vancouver, Mr. M. H. McCabe of Victoria, and others.

[1] Robertson, W. F. (Provincial Mineralogist), Report of the Minister of Mines, B.C., 1904, p. G 81.

A wagon-road 4,300 feet long with a good grade was constructed during the past summer from the tunnel on the Gleaner group (Diag. 4) across the Engineer property, to the shore of Taku arm, from which point there is direct steamboat connexion with Caribou on the White Pass and Yukon railway, 65 miles distant.

Geological Formations.—The rock formations on the Gleaner claims are the same as at the Engineer mines, i.e., they consist mainly of the Jura-Cretaceous shales, slates, greywackes, and tuffs, of the Laberge series, which have been invaded by occasional dykes of andesite and granite porphyry. The sediments are in places somewhat folded, faulted, and distorted, but in a general way have a fairly uniform strike of about N. 60° W. and dip 30° to 40° to the northeast, under the high mountains in that direction.

The Veins.—The ores on these claims are in quartz veins which occur mainly in the dark, finely textured beds of the Laberge series, and four veins at least have been discovered on the property (Diag. 4). No. 1 and No. 2 veins are simple fissure-fillings and consist mainly of quartz. These are exposed on the south bank of Butler creek, strike about N. 20° W., and are from 20 to 30 feet apart. A vein from 3 to 10 inches thick, which is, in all probability, the extension of either No. 1 or No. 2, outcrops on the north side of Butler creek, where it is broken and off-set by a number of faults having displacements of from a few inches to several feet each. On the wagon-road about 750 feet from where these veins cross Butler creek, a vein is exposed (marked No. 4, Diag. 4) which is traceable about 100 feet, strikes N. 20° W., is from 1 to 2 feet thick, and is probably also the extension of either No. 1 or No. 2 veins. On the south side of Butler creek about 80 to 100 feet above No. 2 vein, No. 3 vein is exposed and has a thickness of 3 to 4 feet; this is really only a faulted zone in the formation into which has been introduced a considerable amount of quartz which occurs mainly in the form of narrow stringers and also as a cement uniting the various rock-fragments. About 700 feet from there in a southerly direction in the apparent line of strike of No. 3, is a similar zone or compound vein about 10 feet thick, that is apparently the extension of No. 3 and has been traced for at least 400 feet with a general strike about N. 25° W. No. 5 vein is exposed about 100 feet to the south of the

Glenner tunnel, is apparently about 2 feet in thickness, and strikes approximately N. 15° W.

Quartz is practically the only gangue mineral in these veins, and with the intercalated layers and fragments of wall rock, constitutes nearly the entire vein-filling, with the exception of the small amounts of native gold, iron pyrite, and iron oxide. Where gold occurs it is generally finely disseminated through the quartz, but in places, thin leaves and flakes ½ inch across have been found. This mineral has so far been obtained chiefly in pockets or shoots which are generally small, but during the latter part of this past summer a pocket or shoot was discovered on the north side of Butler creek that contained several sacks of ore, through all of which free gold was plentifully visible to the naked eye.

Development.—Some small open-cuts and trenches have been made on the veins outcropping along Butler creek, and a tunnel 150 feet long has also been driven from a point about 1,000 feet to the south of the creek, that was intended to cross-cut vein No. 3, but so far this quartz deposit has not been encountered.

THE KIRTLAND GROUP.

The Kirtland group is owned by Thos. Kirtland and Captain W. Hawthorn, R.N., and consists of six claims that extend along the east shore of Taku arm from the Engineer group southward to 100 feet or so across Hale creek, a distance of approximately 8,000 feet. The geological formation on this property is the same as at the Engineer mines and on the Glenner group, and the veins that have so far been discovered resemble those found on these properties. However, on the Kirtland group, only a slight amount of prospecting has as yet been performed and this has practically all been confined to the Jersey Lily claim which adjoins the Engineer group. Several simple quartz veins a few inches in thickness, and one brecciated vein 2 to 3 feet thick have been discovered. Two shafts about 10 and 14 feet deep respectively have been sunk and a few open-cuts and trenches have been dug.

Since this property adjoins the Engineer mines and, the formation is apparently identical on the two properties, it is hoped that rich ores will also be discovered on the Kirtland group when the claims have become more thoroughly prospected. So far, only a slight amount of gold has been found.

Gold-Silver Quartz Veins.

GENERAL.

The gold-silver quartz veins are the most widely distributed type of ore deposit in Atlin district, and have been found at a number of points, the most important of which are: on the White Moose group and Rupert group on the west side of Taku arm above Golden Gate; on the Lawson group on Bighorn creek; at the Beavis mine near the town of Atlin; on Munroe and Boulder mountains east of Atlin; and on the Brothon and Alvine claims on Hoboe creek near the head of Torres channel, an arm of Atlin lake.

These veins occur in a number of formations including chloritic and micaceous schists, basic volcanics, and grano-diorite, and have various dips, strikes, etc., but since they occur in widely separated parts of Atlin district, some of which were, while others were not geologically mapped by the writer, sufficient general information has not been obtained to determine whether these veins are genetically related or not, or whether they were formed at the same time or produced by the same agencies, etc. They have been grouped together solely because they possess similar mineralogical characteristics.

Generally these veins consist mainly of quartz, but some also contain calcite as an associated gangue mineral. Galena and pyrite are the most common metallic minerals, but in addition chalcopyrite and tetrahedrite frequently occur, and native gold and native silver are occasionally found. The ores are generally of value mainly for their gold content, but they always contain more or less silver which in places even exceeds the gold in value.

In most places the veins are only slightly oxidized, and everywhere primary minerals are exposed within 5 or 10 feet of the surface, and generally are to be seen in the outcrops. The ores are thus for the greater part primary, and contain everywhere mineral combinations characteristic of the upper vein zone.[1] The veins

[1] The different vein zones are discussed under "gold-tellurium veins."

have also apparently been formed by deposition from mineral solutions which in all probability derived their mineral contents from intrusive igneous rocks, and in the majority of cases at least there appears to be a genetic relationship between these veins and the granitic rocks of the district.

THE WHITE MOOSE GROUP.

General.—The White Moose group is situated on the west side of Taku arm opposite the Engineer mines (Diag. 5) and consists of eight claims which are owned by four persons, three of whom are Dr. H. S. Young, and Messrs. J. Johnson and Robt. Grant. Two veins, distinguished as the North and South veins respectively, have been discovered on this property. Five claims have been located in the valley bottom along the strike of the North vein, and these extend southward along the shore the length of the five claims from a point about one-half mile above the mouth of Buchan creek. The other three claims have been located along the South vein which strikes in a northwesterly direction; and the most easterly of these claims extends to the shore of Taku arm and adjoins the most northerly of those located on the North vein.

Geological Formations.—The rocks in the vicinity of the White Moose group, with the exception of occasional dykes, all belong to the Mt. Stevens group of lower Palæozoic (?) age and consist mainly of finely textured, greenish, schistose amphibolites that are much contorted, faulted, and metamorphosed.

The Veins.—Outcrops that are thought to all be portions of the same vein—the North vein—occur at intervals for a distance of over 5,000 feet, strike in a general direction N. 10° W., and dip to the northeast at angles ranging from 40° to 60°. It is possible, however, that these various exposures represent more than one vein, but they all lie in the same general line of strike, dip to the northeast, contain identical mineral combinations, and in every way appear to have a common origin and to be parts of one fissure-filling; so all these vein-portions are here, for convenience in description, at least, considered as belonging to the same vein.

This so-called 'North vein' varies in thickness from 18 inches to 4 feet, and consists mainly of quartz which is predominately massive, bright, and white to colourless. In places slightly vesicular white quartz occurs, and occasional small patches of white calcite were also noted. In addition to these gangue minerals, the vein is fairly well mineralized chiefly with argentiferous tetrahedrite (grey copper), pyrite, and chalcopyrite (copper pyrite), but galena and malachite (green copper stain) also occur. At the most northerly exposure of the vein, where it outcrops at the shore, a small shaft has been sunk, there the vein is about 2 feet thick and in places is composed almost entirely of metalliferous minerals, mainly tetrahedrite, chalcopyrite, and galena, with subordinate pyrite and malachite. Toward the southern end of the claims on this vein, some trenches and open-cuts have been made, a shallow prospect shaft has been sunk, and a cross-cut tunnel has been commenced, which has, however, not tapped the ore as yet. The vein at the shaft and in the vicinity has an average thickness of about 2 feet, and above the tunnel is 7 feet thick, but is there not so well mineralized as in places where the thickness is less. It is not known at all definitely how much gold and silver the ore in this vein carries, but a number of the assays that have been made gave results of from $10 to $15 in gold and from 20 to 100 ounces of silver per ton.

The South vein is from 6 to 10 feet in thickness, strikes approximately N. 57° W., dips to the southwest at angles ranging from 50° to 70°, and is composed mainly of quartz containing varying amounts of disseminated galena and chalcopyrite; the metallic constituents were nowhere noted, however, in sufficient quantities to constitute any considerable portion of the vein-material. It is not known as yet what this quartz assays.

THE RUPERT GROUP.

General.—The Rupert group is owned by Messrs. Allan Rupert and James Johnson and consists of 8 claims located on the east face of Whitemoose mountain which is situated on the west side and near the upper (south) end of Taku arm (Diag. 3 and Plate XXIX). The property is thus on the lake front very favourably situated for mining purposes.

Geological Formations.—The general rock formation here is the same as on the White Moose property and consists of the mem-

Plate XXIX

Looking in a southeasterly direction up Taku stem. The [illegible] group of [illegible] [illegible] the eastern face [illegible] mountain [illegible]

28627—p. 94

bers of the Mt. Stevens group, mainly the greenish amphibolites which are here decidedly schistose and have been sheared, folded, mashed, broken, and highly metamorphosed.

Description of Veins.—At least five veins outcrop on the Rupert group, and the float from a sixth has been found; these all appear to be approximately parallel and are best exposed on the mountain slope directly above and to the west of Rupert's camp on the west shore of Taku arm. For convenience in description these veins have been numbered consecutively, beginning at the lowest and ascending toward the top of the mountain.

Vein No. 1 outcrops prominently in a gulch at an elevation of about 1,700 feet above Taku arm, strikes about N. 80° W., and is from 2 to 3 feet in thickness. No. 2 vein lies about 300 feet, measured vertically, above No. 1, is from 6 to 8 feet in thickness, strikes N. 73° W., and has a nearly perpendicular attitude. No. 3 vein is from 2 to 3 feet in thickness, outcrops about 70 feet above, and strikes and dips practically parallel with No. 2. No. 4 vein is approximately 950 feet (measured vertically) above No. 1, dips at high angles to the southwest, and is from 4 to 12 inches in thickness. Vein No. 5 appears to be about 4 feet in thickness and is situated approximately 1,300 feet above No. 1, but it was only noted at one point and the strike and dip could not be determined on account of the small extent of the outcrop. Nos. 1, 2, 3, and 4 are each traceable along the s[illegible] for several hundred feet, have fairly persistent strikes [illegible] and appear to be similarly mineralized throughout. [illegible] [illegible]st mainly of quartz which is prevailingly whit[illegible] [illegible]h occasional vugs and bunches of vesicular crys[illegible] [illegible]ed, and in places the quartz is stained reddis[illegible] [illegible] Galena is the prevailing metallic mineral present [illegible] [illegible]paringly distributed through the quartz gangue. [illegible] [illegible]atches of pyrite and native gold also occur. No. 2 vein [illegible] heavily mineralized than the others, and in one place 6 feet of well mineralized ore occurs. The best specimens of native gold are believed to have been found in vein No. 4.

On the top of the hill above No. 5 vein, and lying along the northern edge of the glacier, are a great number of angular pieces of ore some of which are as much as several hundred pounds in weight. This ore is different from that of the other veins, so far discovered on the hill, as the metallic minerals pyrite and galena are more abundant in it, and frequently exceed in amount the gangue; also pyrite is there the most abundant metallic constituent, whereas in the lower veins, pyrite is of somewhat rare occurrence. A heavily mineralized vein of apparently considerable thickness must, therefore, exist under this glacier.

Values.—It is not known what amounts of gold or silver these veins contain, but assays running from $100 to $300 per ton are claimed to have been obtained; however, it is probable that average tests would give results not exceeding a fraction of the smaller of these amounts. The information that has been obtained concerning these veins, however, appears to at least warrant their further exploration and development.

THE LAWSAN GROUP.

General.—The Lawsan group is owned by Fred Lawsan, Thos. Kirtland, Wm. Powell, Robt. Pelton, Dan Sullivan, and Agnew A. Lawsan, and consists of six claims located on the west side of the valley of Bighorn creek (Plate XXX). This property was first staked in 1898, has since this time been owned by several parties, has lapsed twice, and was located by the present owners in 1909. The greater number of the veins that have been discovered are on the Bighorn claim where all the development work has been expended. The British Columbia government during the summer of 1910 constructed a wagon-road from Kirtland on Taku arm up the valley of Fantail river to Bighorn creek, and thence up the valley of this stream to the lower terminal of the aerial tramway on the Lawsan group, a distance of 10 miles, so this property is now readily accessible.

Geological Formations.—The rock formations on this group and in the vicinity, with the exception of occasional dykes, consist of the members of the Mt. Stevens group, of which the finely textured, greenish, amphibolites predominate, and in these the mineral veins prevailingly occur. In addition, micaceous and sericitic schists as well as quartzites occur. Some of the Mt. Stevens rocks are in places quite fissile, and all are decidedly schistose, and have been folded, faulted, crumpled, and so metamorphosed that their original

Looking up the valley of Bighorn creek. The arrow indicates the position of the [illegible] claims comprising the Lawson group. The view also shows the typical character of the valley, and the [illegible] topographic unconformities everywhere encountered at the upper edge of the valley walls.

character has been masked and in some cases entirely destroyed. They have also been invaded by numerous post-Palæozoic dykes of andesite, rhyolite, and granite-porphyry. The formation in a general way strikes about N. 15° E. and dips to the northeast at angles up to 15°.

The Veins.—The veins on this property are lens-shaped and lie practically always conformable to the foliation planes of the enclosing rock. No fissure veins intersecting the formation were noted. The lenses are divisible into two groups which were formed at different times; and the older were affected by pronounced dynamic activity before the newer veins came into existence. All the lenses are quite similar in their general appearance, and the two groups can only be distinguished in the field by observing the faulting.

The earlier veins are much more broken than the later ones, in fact although quartz veins and vein-fragments are plentifully distributed throughout the formation in this vicinity, and outcrops from a fraction of an inch to several feet in width are everywhere to be seen, yet entire lenses more than a few inches in thickness and 5 or 6 feet in length, are of rare occurrence. Some lenses are so faulted that one end only is removed; others are curtailed at both ends; and the original fragments have, in places, been again subdivided so that a considerable variety of forms result. One fragment 4 to 5 feet in thickness was noted that had lost both ends, and only a central portion 10 feet long remained. Another vein with an average thickness of 8 inches outcropped for 60 feet, and one end was complete and terminated in regular lens-fashion, while the other end terminated abruptly showing that an original portion was removed. Many lenses and lens-fragments occur up to 20 feet in length and as much as 2 feet in thickness (Fig. 1).

A few lenticular veins occur however, associated with those just described, that have been formed since the greater part of the faulting occurred, and so have been unaffected by these movements. The largest quartz lens noted was from to 4 to 24 inches in thickness and over 200 feet in length. This is the vein on which the bulk of the work on the Bighorn claim has been performed.

The veins or lenses are composed of quartz which is in places rust-stained and carries small amounts of galena, chalcopyrite,

pyrite, and native gold. Some specimens were seen in which particles of gold existed, which were as much as $\frac{1}{20}$ of an inch in diameter. In other places small flakes or leaves of gold were noted up

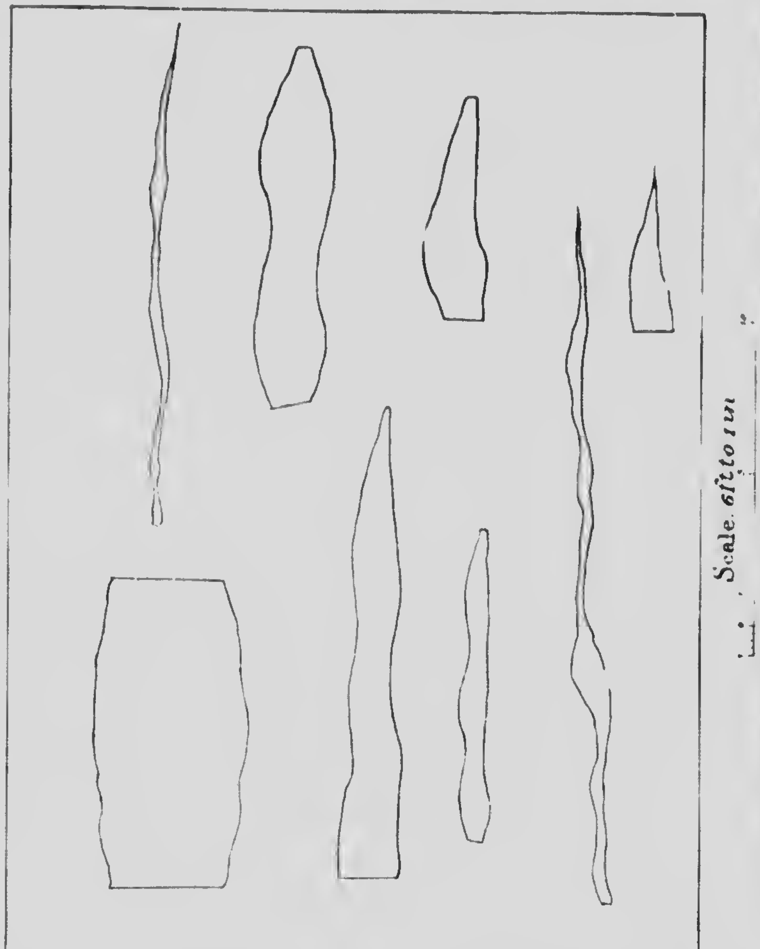


Fig. 4. Diagrammatic sketches showing cross sections of typical members of the older quartz lenses on the Bighorn claim, on Bighorn creek, Atlin mining district, B.C.

to $\frac{1}{8}$ of an inch across. Also from the limited amount of prospecting and assaying that has been performed it has been fairly conclusively demonstrated, for the Bighorn claim at least, that the gold occurs in economically important amounts only in the newer veins, and that the older more broken lenses are practically barren. The owners claim that the 200 foot lens will average $160 in gold and silver to the ton—the bulk of this amount being in gold.

Development.—Two tunnels 55 and 30 feet long respectively have been driven, and some open-cuts and trenches have been made. Also a temporary aerial tramway 1,700 feet long has been constructed to carry the ore from the tunnels down to the valley-bottom.

OTHER CLAIMS ON BIGHORN CREEK.

About 1½ miles north of the Lawsan group, and also on the western slope of the Bighorn valley at a point about opposite Peter's cabin (Diag. 3 and Plate XXX), a fissure-vein outcrops, which is traceable for a distance of at least 3,000 feet, and throughout this distance is remarkably persistent in dip, strike, thickness, and mineralization. This vein cuts the schistose and gneissoid members of the Mt. Stevens group of rocks, has an average thickness of about 3½ feet, strikes N. 56° E., and has an almost perpendicular attitude. The fissure-filling consists almost entirely of quartz throughout which are occasional particles of pyrite. This vein is remarkable for its persistency and for the fact that it is the only fissure-vein noted in this locality. The quartz is believed to carry a few dollars per ton in gold, but none of the known assays so far obtained have given more than $10 per ton in gold and silver.

At least two claims, the 'Birdie' and the 'Gold Cup', owned respectively by Wm. Powell and Fred Lawsan, are located on this vein, and on the Gold Cup two tunnels 35 feet and 160 feet in length respectively, have been driven in on the quartz.

THE IMPERIAL MINES.[1]

General. The Imperial mines are owned by Messrs. T. H. Jones, and James Stokes of Atlin, and William A. Moore of Nanaimo B.C., and consist of four crown-granted claims situated on the south side of Munroe mountain, 5 miles in a northwesterly direction from the town of Atlin to where a good wagon-road has

[1] Robertson, W. F., Report of the Minister of Mines, B.C., 1900, pp. 758, 759; 1904, pp. G 71, G 75.
Gwillim, J. C., "Report on the Atlin mining district, British Columbia," Geol. Surv., Can., Ann. Rep., 1899, Vol. XII, p. 45 B

been constructed (Diag. 3); the entrance to the lower tunnel is 1,030 feet in elevation above Atlin wharf. This property was first located in 1899, and in 1900 was bonded to the Nimrod Syndicate of London, England, who surveyed and crown-granted the claims, built a five-stamp mill and bunk house on the property, and did considerable development. At the end of a year this syndicate abandoned the property and Mr Herbert Pearce obtained an option on it for 2 years, 1901-2. Since this time no work has been performed on the property.

Summary.—All the work at these mines has been expended in developing a single quartz lode which occurs in a finely-textured rock that ranges from a hornblende-diorite to a hornblende-diorite porphyrite. The lode strikes N. 70° E., and dips at angles of 50° to 60° to the southeast. This deposit includes two or three close, parallel, mineralized fissures which contain an aggregate thickness of 2 to 3 feet of vein material consisting mainly of quartz, sparsely distributed through which are particles of galena, chalcopyrite, pyrite, malachite, and occasionally, native gold. A considerable portion of the quartz is thought to contain from $10 to $30 per ton in gold and silver, the silver being relatively small in amount. Two cross-cut tunnels have been driven, which tapped the vein at 25 and 112 feet respectively, and from these over 400 feet of drifts have been driven.

Plenty of water is available at the base of Munroe mountain for crushing and milling requirements, and the falls on Pine creek nearby, would afford ample power for any ordinary mining requirements.

The property thus possesses many natural advantages and contains a considerable tonnage of ore which, although low grade, should prove profitably workable by modern economical methods.

Geological Formation.—The formation at the Imperial mines appears to be chiefly a dark greenish to brownish green, dense, finely textured, rock that is either megascopically entirely aphanitic or contains visible hornblende phenocrysts in an aphanitic groundmass and ranges from a hornblende-diorite to a hornblende-diorite porphyrite. Under the microscope a typical sample proved to be composed largely of plagioclase and pale brownish hornblende, with some accessory iron ore, the hornblende occurring in shreds and irregular prismatic forms imperfectly terminated and constituting nearly half of the rock mass.

Description of Veins. All the work on these claims has been expended in developing one main vein or lode which strikes approximately N. 75° E., dips from 50° to 60° to the southeast, contains, where it has been exposed, from 4 to 7 feet of vein material, and has been traced for a distance of over 500 feet. The vein is not simple in form but includes, in most places, the quartz and associated minerals which have been deposited in several close parallel fissures, and have also replaced more or less of the original intervening wall rock. The vein is thus a compound vein, or since replacement has been effective to a considerable degree in altering the intervening and intercalated rock-portions, the term lode is probably most appropriate.

On account of its compound nature this vein naturally varies considerably in thickness, and is also irregular in strike and dip. The main mineralized fault zone which constitutes this lode is fairly persistent; but the various small included members are quite erratic and in most places the lode is divisible into two or more distinct parts. In the upper tunnel on the property a rather typical section gives:—

	Ft.	In.
Hanging wall....		
Quartz, etc	2	1
Rock somewhat replaced ..	2	0
Quartz, etc	0	7
Rock considerably altered and heavily iron stained	1	6
Quartz	0	7
Foot wall. .		

Another section 30 feet to the northeast shows:

	Ft.	In.
Hanging wall		
Quartz, etc	2	0
Rock, heavily iron stained and somewhat decomposed.	3	7
Quartz, etc.	1	1
Foot-wall .		

The vein-material appears to have an average aggregate thickness of from 2 to 3 feet and consists mainly of quartz which is often iron-stained or rose-coloured, and frequently exhibits crustification and comb-structures, but is also in places quite massive in appearance. Sparsely distributed through the quartz are particles of galena, chalcopyrite, pyrite, malachite, and free gold. Pockets or shoots occur, however, in which these metallic minerals occur plentifully.

In addition to this main lode, numerous other veins and stringers exist on the property, and the lower tunnel has crosscut several fissures that contain from 6 to 8 inches of quartz and associated metallic minerals.

Values and Treatment.—The average amounts of gold and silver this main lode contains are only approximately known, but a considerable portion of the quartz contains probably from $10 to $30 per ton in these minerals, and assays have been made that ran as high as $149 per ton. In 1902 a test sample of this ore weighing 3,267 pounds net, was sent to Pellow-Harvey, Bryant, and Gilman of Vancouver, B.C., who reported the ore to contain:—

Gold, 1·29 ozs. valued at $20.00 per oz.	$25 80
Silver, 1·26 ozs. valued at $0.52 per oz.	0 66
Total	$26 46

This firm also adds: 'The best method of treating this ore would be first to save the gold by amalgamation on the plates from

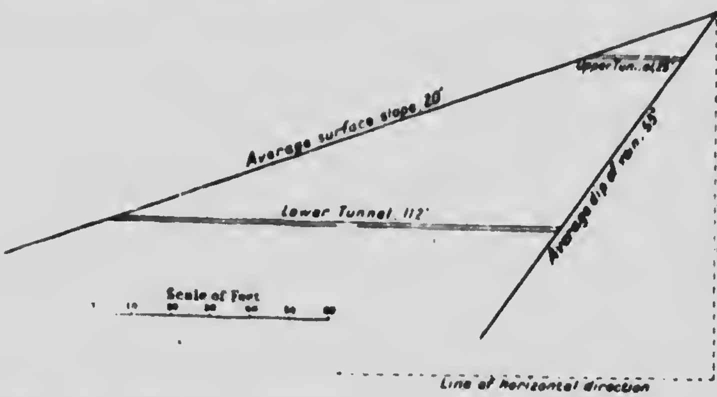


Fig. 5. Diagrammatic section through the workings at the Imperial mines, Atlin mining district, B.C.

a stamp-battery, and then cyanide the tailings, when a total extraction of about 97 per cent of the gold and silver contents should be saved.'

A mill-run, continued for several weeks by the Nimrod syndicate in 1900 upon the ore of this vein, gave, according to their published report, a little over $10 per ton in gold.

Development. As the average slope of the south face of Munroe mountain is about 30°, and the vein dips in the same direction but at an average of approximately 55°, the ore gradually gets farther from the surface of the mountain, but until the foot of the mountain is reached the vein is readily accessible by crosscut tunnels (Fig. 5). Two crosscut tunnels have been driven: the upper tunnel tapped the vein at a distance of 25 feet and the lower one reached the ore in 112 feet. From the ends of these tunnels, drifts have been driven in both directions, and 580 feet, in all, of underground work has been performed.

THE BEAVIS MINE.[1]

The Beavis mine is owned by the Gold Group Mining Company, Limited, in which Messrs. H. Maluin and Wynn Johnson are the principal shareholders. This property consists of nine mineral claims, three of which are crown granted, and is situated on the east shore of Atlin lake 1½ miles north of the Atlin post office (Diag. 3).

Several thousand dollars have been expended in the development of these claims, mainly by two shafts which when visited in October 1910, were filled with water, so that no definite information could be obtained concerning their depths or the character of the ore deposit. From the material exposed on the dump, the rock in the shafts appears to be mainly black chert and chert breccia, but a granite-porphyry dyke also cuts the formation in this vicinity. The ore apparently consists of a quartz vein carrying some pyrite and free gold.

BOULDER MOUNTAIN CLAIMS.

General.—A number of claims have been located on the east slope of Boulder mountain between Birch and Boulder creeks, about 12 miles in a northeasterly direction from Atlin; of these the White Star Group[2] (Diag. 3) of three claims owned by Captain Wm.

[1] Robertson, W. F.—Report of the Minister of Mines, B.C. 1901, p. 786.
[2] Robertson, W. F. Report of the Minister of Mines, B.C., 1901, p. G 76, G 77.

Hathorne, R. N., and the Lake View group[1] (Diag. 3) of three claims owned by Jos. Clay have been the most explored. Other claims between and adjoining these groups are also being held, and on some of them the same veins are supposed to outcrop that are found on the Lake View and White Star properties.

The formation in the vicinity of these claims consists of the members of the Mt. Stevens group of rocks, mainly the amphibolites, sericitic schists, quartzites and limestones.

The White Star Group.—On the White Star group two veins have been discovered, of these, the upper one occupies a fissure in fine textured schistose amphibolite, is from 4 to [illegible] feet in thickness, strikes N. 70° W., dips to the southwest at angles ranging from 80° to 85°, and outcrops at an elevation of 1,650 feet above the lower end of Surprise lake. This vein consists mainly of quartz which is sparsely mineralized with galena, pyrite, and occasional particles of native gold. A tunnel 58 feet long has been driven on the ore.

Approximately 400 feet down the mountain slope from this upper vein is an exposure of quartz across which a trench 30 feet long has been dug without coming to its edges, so that the dip, strike, etc., of this deposit are not known. The quartz contains occasional particles of pyrite and iron oxide, but has not been found to carry any other metallic minerals.

The Lake View Group. On the Lake View group two veins have also been discovered that are about 400 feet apart and strike approximately in the direction of the White Star group. These are thought by the owners to be probably the same veins as those found on the White Star property but sufficient work has not yet been performed to justify this conclusion.

The upper vein on the Lake View group is from 3 to 4 feet, and the lower one is about 30 inches in thickness. The quartz of both is sparsely mineralized with galena, pyrite, and rare specks of native gold. A tunnel over 100 feet in length has been driven, two shafts about 35 and 27 feet deep respectively have been sunk, and a number of trenches and open-cuts have been dug on this

[1] Robertson, W. F., Report of the Minister of Mines, B.C., 1901, p. 76. Gwillim, J. C. Ann. Rep., Geol. Surv., Can., Vol. XII, 1899, p. 76A.

group of claims, with the result that the two veins thereon have been traced for several hundred feet.

General Values. A few samples have been obtained from these Boulder Mountain deposits that assayed from $100 to $500 per ton and one or two are even claimed to have given higher results, but an average of the veins would probably not exceed $10 and might be somewhat less. From the various tests that have been made, however, it is hoped that some of this quartz will pay for mining when such can be conducted economically. In all probability numerous other veins will be discovered in this vicinity, as the mountain is in most places covered with a mantle of superficial materials that hide the bed-rock and whatever ores it contains.

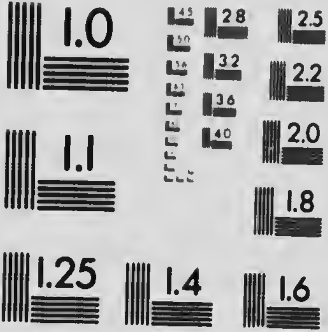
THE LAVERDIERE GROUP.

General. The Laverdiere group is owned by three brothers, Messrs. Noel, Frank, and Thomas Laverdiere, and consists of six claims, three of which are crown-granted, and two fractional claims. This property is situated on the west side of Hoboe creek, about 2 miles from where it runs into West bay which forms the upper end of Torres channel, an arm of Atlin lake. The principal ore-body on the Laverdiere group, or at least the one most highly valued and that on which the bulk of the development has been expended, is described under 'contact metamorphic deposits.' In addition two fissure-veins have been discovered on the Alvine and Brothers claims respectively, that appear from the limited amount of work that has been performed on them, to belong to the 'gold-silver quartz veins' and so will be here described. It is possible, however, that they would be more appropriately classed under 'high-grade silver veins.'

The Alvine Claim. The vein on the Alvine claim strikes approximately N. 30° W., has an average thickness of about 2 feet, and occurs in the Coast Range granitic rocks. This deposit consists almost entirely of a gangue of quartz which is in most places somewhat stained with iron-oxide, and with which is associated a small amount of white calcite. Disseminated through this gangue is nearly everywhere more or less argentiferous tetrahedrite (grey copper containing silver); occasional small particles and flakes of native silver also occur. It is not known what this ore will assay,

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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but its general appearance warrants the expenditure of sufficient work to more thoroughly explore the vein.

The Brothon Claim.—On the Brothon claim, another mineralized fissure occurs in the Coast Range granitic rocks, strikes N. 25° E., has an almost vertical attitude, and can be traced from near the level of the valley-bottom several hundred feet up the mountain side. In places this fault includes between its walls several inches of quartz which is associated with some calcite, and contains more or less galena and tetrahedrite, and also occasional particles and flakes of native silver. Near the valley this fissure includes only about one-fourth of an inch of decomposed clayey material through which, and the somewhat altered and replaced walls for 6 and 14 inches on each side of the fault, is a certain amount of disseminated argentiferous tetrahedrite and native silver. Assays of the mineralized wall-rock have been obtained that gave results as high as 600 ounces and it is claimed that a zone 12 to 14 inches in thickness, bordering the fissure, will average from 20 to 30 ounces of silver per ton.

Cupriferous Silver-Gold Veins.

GENERAL.

The veins considered in this report as belonging to the cupriferous silver-gold class, have been found in Atlin district only on Table mountain which is situated on the north shore of Graham inlet opposite Taku Landing. The only two deposits on this mountain that have been at all developed occur on the Petty and Dundee groups respectively, and occur in granite-porphyry which is intrusive in Chieftain Hill andesites and andesitic tuffs. The veins consist mainly of quartz, calcite, galena, chalcopyrite, pyrite, malachite, and azurite, which minerals occur also to some extent disseminated through the wall rocks. The Petty vein where exposed is from 6 inches to 2 feet in thickness and has been traced for over 100 feet; the Dundee vein has a maximum known thickness of 2½ feet, but has not been followed more than 50 feet.

THE PETTY GROUP.

The Petty group is owned by Mr. Ira Petty and consists of two claims which are situated on the southeastern corner of Table mountain, overlooking Graham inlet, and are about 31 miles in a northwesterly direction from Taku Landing (Diag. 3).

The rock formation in this vicinity consists mainly of the Chieftain Hill volcanics which are here prevailingly greenish andesites and andesitic tuffs. These have been extensively invaded by dykes of granite-porphyry, belonging to the Klusha intrusives.

Only one main vein has been so far exploited on the Petty group, and this occurs in the granite-porphyry, strikes N. 30° E., and has an average dip of about 40° to the northwest. The vein consists mainly of quartz, calcite, galena, chalcopyrite, pyrite, malachite, and azurite, and one small cavity was found to be lined with small crystals of the rare mineral linarite (a basic sulphate of lead and copper). The quartz is generally rust-stained and occurs associated with varying amounts of calcite which in places even exceeds the quartz in amount. Galena and chalcopyrite are the most abundant ore-minerals present, and occur in approximately equal amounts and in sufficient quantity in places to constitute the greater portion of the vein-material. This vein has a thickness, at the widest point so far discovered, of about 2 feet, but rapidly diminishes to 6 inches or less within a distance of 50 feet in each direction, and has not been followed for over 100 feet. It is possible, however, that further development may show the vein to extend a somewhat greater distance. In addition, several other mineralized fissures occur in places on both sides of this main fissure, and within distances of 1 to 2 feet from each wall; and the rock between these is to some extent replaced and impregnated with various orematerials; so that at the main shaft the ore might be considered to have a total thickness of 3 feet at the surface, but towards the bottom of the shaft its thickness is much less. The ore is claimed to contain four or five dollars per ton in gold, with the main values in silver and copper; but so few tests have been made, that it is uncertain what average amounts of these metals the ore carries.

An inclined shaft 90 feet deep has been sunk on the ore, commencing at the most promising-appearing point on the surface, and within 50 feet an open-cut has also been dug. A trail has been made from the shore up to the workings, which are about 1,200 feet in elevation above, and directly overlooking Graham inlet.

THE DUNDEE GROUP.

The Dundee group is owned by the British Crown Gold and Copper Mining Co., of Victoria, B.C. This Company was incorporated November 29, 1909, for $1,000,000, with Mr. Scott I. Wallace, of Seattle, Wash., as Secretary-Treasurer, and Messrs. W. W. Felger, F. G. Holder, A. C. Pellissier, and Wm. F. Howe as directors. The property consists of two adjacent claims one of which, the Dundee, adjoins the Petty group to the northeast in the supposed direction of strike of the Petty vein (Diag. 3). The formation on the Dundee group is the same as on the Petty claims, and the ore also occurs associated with a granite-porphyry dyke. Only one vein has been developed on this property and this strikes N. 30° E., dips to the northwest at 40° to 50°, is lens-shaped, and for 10 or 15 feet has a thickness ranging from 1 to 2½ feet. Thirty feet to the northwest from this point of greatest thickness at the surface, the vein is not more than 1 inch thick, and it cannot be traced more than 20 feet to the southwest. It has been supposed that this is the same vein as that on the Petty group, as both strike in the same direction; however, there appears to be no support for this assumption as the vein on the Dundee claim distinctly terminates within 100 feet, at most, of the places where it outcrops, in the direction toward the Petty claims; this is clearly evident from the fact that the rocks are all well exposed in a draw 100 feet from the outcrop of the Dundee vein in a direction toward the Petty shaft, and although any vein crossing this draw would readily be seen, none is to be found. Further, if the vein continued from the Petty shaft in the line of strike it there maintains, it would pass considerably above the showing on the Dundee claims.

The Dundee vein is similar in appearance to that on the Petty group and consists of a quartz and calcite gangue highly impregnated with galena, chalcopyrite, malachite, and azurite. The wall-rock also contains a considerable amount of these minerals disseminated through it. Instead of following a fissure in the central portion of a granite-porphyry intrusive, however, as in the Petty group, the vein continues near the edge of a granite-porphyry dyke, but was nowhere seen to depart from this rock into the adjoining andesitic materials.

Two tunnels having lengths of approximately 20 and 150 feet respectively, have been driven on the Dundee claims, but neither have cross-cut the vein; two small open-cuts have also been dug. A trail has been constructed from the shore of Graham inlet up to the higher of these workings which is about 700 feet above and directly overlooking the water.

THE PELTON GROUP.

The Pelton group is owned by Mr. R. L. Pelton, of Taku Landing, and consists of two claims which adjoin the Dundee group in the direction of the general line of strike of the vein on this property (Diag. 3). The rock formations on the Pelton claims are the same as on the Petty and Dundee groups, but no ore has as yet been encountered.

Silver-Lead Veins.

GENERAL.

Silver-lead veins are known to occur in Atlin district, only on Mt. Leonard, on the north face of which, in the vicinity of Crater creek, are located the main deposits of this class examined by the writer. When the locality was visited in October, 1910, about a dozen claims were held on Crater creek and in the vicinity; of these, those on which the most development had been performed, and which have the most promising appearance, belong to the Big Canyon group (Diag. 3). Two smaller veins on adjoining ground were also seen. A number of other veins are known to occur in the vicinity, but owing to the lateness of the season and stormy weather with considerable snow, these were not examined.

The veins seen are all strikingly similar and vary chiefly only in size and degree of mineralization. The ores all occur in dark-greenish diabase dykes which have invaded the surrounding granitic formation, and the general description given below of the deposits on the Big Canyon group applies to all the veins in the vicinity.

BIG CANYON GROUP.[1]

Summary.—The Big Canyon group consists of four claims which were located in 1899 and are owned by Messrs. John Malloy, Thomas

[1] Robertson, W. F., Report of the Minister of Mines of British Columbia, 1900, p. 760.
Gwillim, J. C., "Report on the Atlin mining district, British Columbia," Geol. Surv., Can., Ann. Rep., Vol. XII. 1899, p. 45B.

Vaughan, and M. Summers. Two main veins occur on this property, the lower of which crosses Crater creek just below the forks of the stream, and the upper vein crosses the west branch of the creek a short distance above the forks. In addition, several smaller veins have been found.

The veins are really mineralized diabase dykes which cut the general granitic formation. The upper mineralized dyke, above mentioned, has a width of about 30 feet and is traceable for at least 3,000 feet, and wherever noted is from 8 to 15 feet thick. The lower main ore-bearing dyke is 30 feet thick and is traceable on the surface for several hundred feet. From one-third to one-half of both dykes appear to consist of ore-minerals, chiefly galena, arsenopyrite, pyrite, zinc, blende, quartz, calcite, and ankerite. These minerals occur filling fissures and other cavities in the dykes, and also, in places, have more or less replaced the brecciated dyke material.

The veins contain only small amounts of gold, generally less than $4 per ton, but are believed to contain more important amounts of lead and silver, and are at least deserving of further careful exploration and development.

Geological Formations.—The formation on the Big Canyon group consists mainly of a coarsely textured, light coloured, granitic rock which in many places is porphyritic and contains feldspar phenocrysts often exceeding an inch in length. This formation has been extensively invaded by dark-green, finely-textured, diabase dykes which are everywhere in evidence. The ore deposits occur prevailingly entirely within the volcanic intrusives, but in a few places were noted to lie at the contact between these and the granitic rocks, and in all cases seem to be genetically related to the dykes.

Description of the Veins.—Two main mineralized dykes or veins occur on the Big Canyon group; of these, one crosses the right branch of Crater creek possibly 300 or 400 feet above the forks of the stream and the other meets the main creek a short distance below the forks.

Upper Vein.—The upper dyke strikes N. 40° E., dips at 80° to 85° to the northwest, has an average thickness of about 30 feet, and is traceable on the surface for at least several hundred feet. This dyke where exposed and explored on the left bank of the creek, is roughly divisible into three parallel bands or zones of about equal thickness.

Plate XXXI

Photographs of polished specimens of ore from the central portion of the 30 feet mineralized dyke on the Big Canyon group, Atlin mining district, B.C. The galena, zinc blende, ankerite, and other ore minerals are seen penetrating and replacing the original dyke material.

28627—p. 110.

The upper zone has been subjected to repeated faulting, and now consists dominantly of brecciated fragments cemented together mainly with infiltrated quartz, there being an increasing proportion of cement as the central portion of the dyke is approached. The upper edge of the dyke thus consists mainly of rock which decreases gradually until at a distance of about 10 or 12 feet, there is a predominance of vein materials.

The middle zone of the dyke contains the bulk of the ore which occurs partly in one or more fissure-veins and numerous narrow veinlets, and also to a considerable extent in irregularly shaped bodies, bunches, etc., which lie between or have replaced the breccia fragments. Metasomatic replacement is here very clearly and vividly illustrated—rock-fragments occurring in all stages of transition, from those consisting entirely of original dyke materials, to others completely altered to secondary ore- and vein-matter, with the original shapes generally still preserved. Galena and arsenopyrite (arsenical iron pyrite) are the prevailing ore-minerals, but pyrite, zinc blende, and ankerite[1] also occur. In addition to these minerals, a certain amount of quartz and calcite, and more or less altered dyke rock occur constituting the gangue of the ore. In places, however, the ore contains almost no quartz or calcite, and in one of the tunnels in this dyke a body 4 feet in thickness was noted composed almost entirely of galena.

The lowest 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 composed mainly of galena, arsenopyrite, and altered dyke-rock.

Lower Vein.—The lower of the two main ore-containing dykes on Big Canyon group strikes N. 40° E., dips at angles 80 to 90° the northwest, is traceable for at least 3,000 feet and possibly considerably farther, and is wherever seen from 8 to 15 feet wide. This dyke, in a general way, much resembles the upper one just described, but is not characterized by distinct zones or persistent bands, and the ore varies in position from place to place, being generally best, however, near the foot-wall. From 4 to 12 feet of this dyke is heavily mineralized mainly with galena, zinc blende, and arseno-

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[1] $CaCO_3 + (Mg, Fe, Mn) CO_3$, or a dolomite in which magnesia is more or less completely replaced by protoxide of iron or of iron and manganese.

pyrite, but pyrite as well as chalcopyrite (copper pyrite) also occur. As in the upper vein the ore occurs in fissures and irregular cavities, and also constitutes irregular bodies, bunches, particles, etc., replacing the original dyke rock. In the cavity fillings considerable quartz and calcite occur, but these minerals are almost entirely absent where metasomatic processes have been prevailingly effective.

Other Veins. In addition to these two main bodies, a number of small veins, generally a few inches in thickness, were noted, which possess the same general appearance and characteristics that distinguish the larger deposits.

Origin of Deposits.—In the deposits on the Big Canyon group, as well as those elsewhere in the vicinity, both the filling of cavities, including fissures, and the replacement of the original rock have been instrumental in producing the ore deposits; but, of the two processes, replacement appears to have been the more effective.

A most striking feature in connexion with these deposits is the persistency with which the faulting and subsequent mineralization adhere to the andesitic dykes. In one place a fault, or rather a fault zone, was followed for over 4,000 feet, and for this entire distance it remained confined to a dyke that nowhere exceeds 15 feet in width; and at no point, as would almost be expected, does the fracturing extend into the granitic rocks on either side. This phenomenon is apparently due to one or both of two causes. In the first place, there appear to be a number of old well-defined lines of weakness in the formation in this locality and at the time of the andesitic intrusion the main dykes followed these, and since this time the various stresses to which the earth's crust has been here subjected have found relief along the same lines. It may also be that the dyke-materials are more brittle and less resistant to the forces that have here been active than the granitic rocks, and that on this account mainly the fractures have been confined to the dykes. Whatever the cause, it is evident that faulting has been active along these definite lines for a long period, commencing before the andesitic intrusion and continuing possibly to the present time, but at least until long after the bulk of the ore and vein-materials were deposited in the faulted and brecciated dykes, as more recent veinlets were discovered cutting portions of the deposits in practically their present condition.

Values.—The ores of the two larger deposits on the Big Canyon group contain only small amounts of gold, generally less than $1 per ton. They are believed to carry more important amounts of lead and silver, although, however, it is not definitely known even, what average amounts of these metals they contain, but from the information obtained it is thought that, although they are decided low-grade, these ores are, nevertheless, sufficiently extensive, and hold enough lead, silver, and gold to make them worthy of careful exploration and investigation.

Development.—On the upper vein two tunnels have been driven the lengths of which could not be determined on account of ice in them, but they probably have an aggregate length of over 100 feet. On the lower vein a shaft possibly 40 or 50 feet deep has been sunk and several open-cuts and shallow pits have been dug. Two crosscut tunnels have been commenced but have not tapped the ore as yet. There are in addition a number of open-cuts, trenches, etc., at different points on this property.

OTHER DEPOSITS.

A dyke crosses Crater creek at a point about 300 feet lower, in altitude, than the outcrop of the upper vein of the Big Canyon group, on the right fork of the stream. This dyke strikes N. 27° E., dips from 80° to 90° to the southeast, and is about 5 feet in thickness. Where it is exposed on the right bank of the creek, about 2 inches of ore occurs on the hanging-wall of the dyke, and on the left bank of the creek, where the ore is claimed to be considerably thicker, a short tunnel has been driven which when visited had so caved in that the hanging wall side of the dyke was not visible. The ore seen was very similar to that in the Big Canyon veins.

At approximately 1,500 feet in an easterly direction from the showings on the Big Canyon group on Crater creek, another dyke occurs which is about 3 feet in thickness, strikes N. 40° E., and has an almost perpendicular attitude. This dyke has been subjected to faulting and brecciation until it is now composed almost entirely of rock-fragments more or less cemented with quartz, calcite, galena, arsenopyrite, and zinc blende. In places the secondary minerals constitute about half of the filling between the granitic walls. A shaft about 30 feet deep has been sunk on this material.

Besides these, a number of similar, and promising deposits of ore are believed to occur in the vicinity, but on account of the lateness of the season and the prevailing stormy weather, they were not examined.

Copper Veins.

General.—Copper veins are known to occur in Atlin district at only one point which is situated on the southwestern corner of Copper island[1] in Atlin lake (Diag. 3). Several claims were held there for a number of years by the Laverdiere brothers, but were allowed to lapse during the year 1910.

Geological Formations.—The rock formation consists of reddish and greenish, prevailingly coarsely textured, olivine basalts and tuffs; the tuffs, however, predominate and in places consist almost entirely of basaltic fragments, but grade into rocks containing a predominance of sedimentary materials.

The reddish basalts range in colour from brownish red to greenish red, and are distinctly basaltic in habit. The groundmass is always cryptocrystalline and contains phenocrysts of olivine and augite as well as particles of iron and occasionally native copper, all of which are readily visible to the unaided eye. In places the groundmass becomes relatively small in amount, causing the rocks to have a decidedly granular appearance.

Under the microscope typical specimens of this reddish basalt proved to be composed largely of basic plagioclase, augite, olivine, and iron ore. The feldspars occur in diverse-tabular, lathe-shaped, forms somewhat altered to saussurite. The augite phenocrysts are mainly idiomorphic and quite fresh in appearance. The original olivine individuals are idiomorphic, but have become almost entirely altered to serpentine, calcite and magnetite. The feldspar, augite, and olivine, with their alteration products, also occur in the second generation, and with the iron ore, constitute the groundmass which varies in amount from about one-half to one-seventh of the entire rock. Iron ore, with which is associated particles of native copper, in places constitutes the greater part of the groundmass.

The greenish basalts are characteristically dark olive-green in colour, and differ from the reddish varieties, chiefly, in containing much less iron, to which is due the red coloration.

The Veins.—A number of veins from a fraction of an inch to 6 inches in thickness occur in fissures in these basaltic rocks, and

[1] Robertson, W. F., Report of the Minister of Mines of British Columbia, 1904, p. G 80.
Gwillim, J. C., "Report on the Atlin mining district, British Columbia," Ann. Rep., Geol. Surv., Can., Vol. XII, 1899, pp. 69A and 46B.

consist mainly of calcite, but also, in places, contain particles and masses of native copper, the largest of which known to have been found, is reported to have weighed about 1½ pounds. A certain amount of malachite (common green copper stain), as well as rare particles of cuprite (red oxide of copper), and tenorite (black oxide of copper) occur as oxidation products of [illegible]e native copper.

Origin of the Copper.—The copper both in the veins and adjoining basalts undoubtedly formed or was deposited in the native form as it now exists, as there is no evidence, such as remnants of unoxidized sulphides, to [illegible]icate in any way that this mineral is a product of the oxidized zone. The magnetite with which the copper is associated is generally quite fresh, and the rocks and veins are only slightly oxidized except at the very surface; also the copper, both on t[illegible] surface and in the various claim workings, is all native except [illegible] the slight amount of surface oxides derived from it. In addition, even if there were no other evidence to show that the copper is a primary mineral here, it is known that throughout this northern district where surface waters are cold and hence chemically inactive, oxidation processes proceed very slowly and no ore deposit has been discovered where primary minerals do not exist within 10, and generally 1 or 2 feet of the surface. Therefore, it is entirely improbable that on Copper island oxidation would have succeeded in so completely altering the original copper minerals both in the veins and adjoining rocks that no traces of them now remain. It thus seems safe to assume that all [illegible] copper in that locality was deposited in the native form.

It remains to determine whether the copper in the [illegible]s is a primary constituent or has been introduced since their formation. As this mineral occurs intimately associated with the iron which is decidedly primary to the basalts, it might be supposed that the copper had the same origin. However, the copper both in the veins and walls is quite the same, and that in the veins in a calcite gangue is unquestionably secondary to the basalts. Some have supposed that the vein copper has been leached from the adjoining walls where this mineral is thought to be a primary constituent. If this were so there would be a decreasing amount of copper in the walls as the veins are approached. Instead, quite the opposite appears to be the case, and the copper is much more plentiful in the basalts adjoining veins and other fissures. It, therefore, seems evident that all the copper both in the walls and veins was deposited at the same period and was introduced by uprising solutions, probably deriving their mineral content from the still heated lower portions of the basaltic magma, and that the great amount of iron ore in the upper cooler portions of the basalts caused the copper to deposit in the native form.

Economic Importance.—The copper so far discovered in these veins is not sufficient in amount to be of commercial importance, and although native copper is believed to be distributed to some extent throughout all the reddish basalts on the southwest corner of Copper and adjoining islands, still from the tests so far made it does not appear to occur in sufficient amount to make these rocks with their included veins profitably workable. It is possible, however, that points may yet be found in this basalt belt, where copper is much more plentiful than at the points so far exploited.

Antimony Veins.

Antimony veins were noted in Atlin district at only one point which is situated on the west shore of Taku arm about 10 miles below (north of) Golden Gate. Two claims, the 'Lake Front' and the 'Antimony,' have been located there by Messrs. James Johnson and C. B. Dickson (Diag. 3) respectively.

The ore occurs in the form of bedded veins that conform, in a general way, to the stratification planes of the enclosing rocks which lie almost flat and consist mainly of the dark greyish to almost black, finely textured, shales of the Jura-Cretaceous, Laberge series.

The main vein is from 3 to 4 feet in thickness and is composed chiefly of quartz and stibnite (antimony sulphide) with also some galena, and includes, as well, varying amounts of intercalated shale. In some places the entire 3 or 4 feet are composed of vein-materials, but in others, beds of shale occur separating the layers of quartz, and constitute about one-half of the material which is, in a general way, regarded as the vein or ore-body. The quartz is generally quite heavily mineralized.

In addition, a number of bedded veinlets ranging in thickness from a fraction of an inch to 2 or 3 inches occur within 6 feet of the upper edge of this vein.

As these ore-materials occur practically at the water's edge, and lie almost flat, it is not known whether there are other parallel veins below the main deposit or not. The bed-rock is there also nearly everywhere covered with Pleistocene and Recent superficial materials, so that the veins have not been traced more than 10 feet along the surface. Further, a drift about 15 feet in length constitutes the bulk of the development on these veins, so that very little is really known concerning them.

Contact-Metamorphic Deposits.

GENERAL.

Contact-metamorphic deposits of economic interest have been found in Atlin district in only one locality which is situated on Hoboe creek near the upper end of Torres channel, an arm of Atlin lake (Diag. 3).

The valley of Hoboe creek has an average width of about one-half mile, is flat, and contains numerous, swampy meadows which are the result, to a great extent, of beaver dams at different points on the stream. Schists, quartzites, limestones, etc., of the lower Paleozoic (?) Mt. Stevens group apparently underlie a considerable portion of this valley and, for a distance of approximately 2 miles from Torres channel, extend up its western slope as well. Adjoining these rocks on the west are the Coast Range granitic intrusives which constitute the high, steep-sided hills to the west and south. The contact-metamorphic ore deposits are included in the Mt. Stevens rocks near their contact with the granitic intrusives.

Along this contact, the Laverdiere and the Callahan groups of claims have been located (Diag. 3).

THE LAVERDIERE GROUP.[1]

General.—The Laverdiere group is owned by three brothers, Messrs. Noel, Frank, and Thomas Laverdiere, and consists of six claims, and two fractions. Three of the fractions were located in 1899 and have since been crown-granted. In addition to the contact deposit which is here described, two mineral veins have been discovered on this property and are described above under 'gold-silver veins.'

[1] Robertson, W. F. Report of the Minister of Mines of British Columbia, 1904, pp. G 79, G 80.

The main workings on the Laverdiere group are situated on the western edge of the valley of Hoboe creek, 1½ to 2 miles from the mouth of the stream.

Geological Formations.—The Mt. Stevens rocks which outcrop along the western edge of the valley consist prevailingly of finely textured, greenish, schistose amphibolites, greenstone schists and limestone. Cutting these and lying to the west and southwest of them are the Coast Range granitic intrusives which are prevailingly light grey or pink coarsely textured, granodiorites. The ore prevailingly occurs in the older rocks and near their contact with the intrusives.

Description of Deposits.—The ore-deposit is at one point approximately 150 feet in thickness, and wherever a section of the rocks below the granitic intrusives has been seen, at least 30 to 40 feet of ore-material has been found; this consists mainly of magnetite, hematite, chalcopyrite, tetrahedrite (grey copper), malachite, cobalt bloom, and various silicates including considerable yellow garnet, apparently grossularite, and some biotite. Typical samples of these ores were supplied to Mr. R. A. A. Johnston, Mineralogist, of the Geological Survey, who states: 'These specimens consist of an association of magnetite, chalcopyrite, and occasional small amounts of tetrahedrite with altered gangue material made up of mixed carbonates and silicates of indefinite composition. The more important minerals in these specimens are sometimes sufficiently well segregated to admit of easy recognition, but in general they are so intimately mixed with each other and with the gangue materials that they can be separated only with very great difficulty; these mixtures are so intimate at times as to at first sight present a homogeneous aspect; this intimacy of mixture not only affects the appearances of the different constituent minerals but it also has the effect of greatly modifying the tarnish colours produced through oxidation; this applies particularly in the case of chalcopyrite which tarnishes to a brownish colour and presents almost the appearance of some pyrrhotite.'

The rock that has been altered and replaced in the formation of the ore-materials appears to have been mainly, if not entirely, the limestone which occurs in bands of varying thickness in the Mt. Stevens series, but in places the limestone has suffered merely recrystallization and marbleization.

The best showing is perhaps on the French claim, on which a cross-cut tunnel 188 feet long has been driven of which more than 130 feet is in the ore-body; this assays from 1·65 per cent to 6 per cent copper, and it is thought that a considerable portion of it will average between 2 per cent and 4 per cent. Numerous faults having displacements of generally only a few inches or a few feet, were encountered in the tunnel, with the result that in some cases blocks of ore were found adjoining others of rock. The deposit extends up to within a few feet of the granodiorite contact which is about 50 feet in elevation above the valley.

A few hundred feet up the valley from the French tunnel, the contact and its associated ore, by persisting in their southeasterly strike, extend from the hillsides out into the valley-flat, and are there lost to view, but probably again outcrop on the hills to the southeast.

On the Holy Cross claim a tunnel has been driven 35 feet but has not yet been run sufficiently far to reach the main portion of the ore-body. Above the tunnel, however, the ore deposit outcrops and is there 40 feet in thickness, and is composed dominantly of granular magnetite, but contains minor amounts of chalcopyrite and malachite as well as erythrite (cobalt bloom) which is disseminated through the ore in places and also occurs coating weathered surfaces. The ore here, as on the adjoining French claim further up the valley, extends up the hillside to within a few feet of the contact between the schistose and granitic rocks, which is about 55 feet above the valley bottom. The ore in the Holy Cross tunnel contains less copper than that in the French tunnel and does not, probably, average more than 1 per cent. All the ore on the Laverdiere group is reported to contain small amounts of silver and gold.

Genesis and Age of Deposits.—In studying the genesis of these deposits a number of striking and definite points have been noted. In the first place, the minerals constituting the ore-body or ore-bodies are chiefly magnetite, specularite, hematite, chalcopyrite, tetrahedrite, pyrite, yellow garnet, and other complex silicates. This combination of hematite and magnetite with sulphides is very characteristic of contact-metamorphic deposits and is practically unknown in fissure veins. Further, when these minerals occur with yellow garnet and related silicates an association is produced which is diagnostic of contact-metamorphism. These same individual minerals may occur in regional-metamorphic ores, but it is highly improbable that a regional-metamorphic deposit should include at one time, and within a few feet, all these minerals which are so characteristic of contact-metamorphic deposits, and no others.

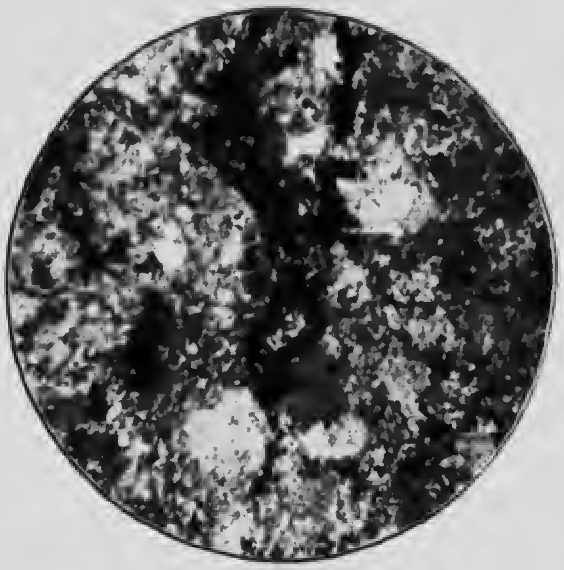
Further, these ore-minerals occur only near the intrusive grano-diorite contact, and have distinctly been produced by replacing the limestones intercalated in the Mt. Stevens series. Plate XXXII shows the ore-materials, largely the garnet and iron-ore, distinctly penetrating and replacing the original rock.

There thus appears to be little or no doubt, but what these ores owe their origin to the neighbouring grano-diorites, and that the materials composing them were derived from the grano-diorite magma, as the limestones and adjoining schistose rocks do not contain the necessary iron, copper, and sulphur for their production.

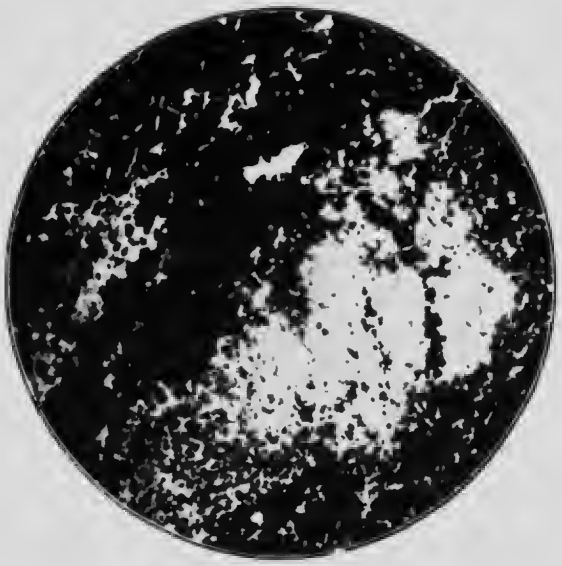
As to the cause of contact-metamorphism [1], petrographers agree that this is due to the heat of the molten magma, combined with the action of water which it contains. In many cases, no perceptible accessions of substance from the magma have taken place, while in perhaps as many others, important additions have been received. The amount of material that is derived from the intrusive body appears to be due mainly to two circumstances, the amount of water-gas in the molten igneous body, and the susceptibility of the invaded rock. In many intrusives, there may be present only a very small amount of water-gas, and thus the accession of material to the invaded formation may be slight and the contact phenomena mostly due to the heat of the rock; if, however, the water vapour is abundant, the amount of material given off may be very great. Magmatic waters also vary widely; some contain large amounts of boron, fluorine, chlorine, etc., while others hold none of these, and possess chiefly sulphur, copper, iron, and related minerals. Thus a wonderful variety of contact-metamorphic deposits are found.

The contact ore-materials on the Laverdiere and Callahan properties are, therefore, in all probability due to magmatic vapours rich in iron, copper, and sulphur, which were derived from the granitic

[1] Lindgren, Waldemar, "The character and genesis of certain contact deposits, T.A.I.M.E., Vol. 31.
Barrell, Joseph, "Physical effects of contact-metamorphism," Amer. Jour. of Sci., Vol. 13.



A. Taken with parallel nicols.



B. Taken with crossed nicols.

Microphotographs of thin sections of ore from the French claim of the Laverdiere group, on Hoboe creek, Atlin mining district B.C. The dark ore minerals are distinctly seen interpenetrating and replacing the original calcite.

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intrusive body. If this is true the deposits were formed during the cooling period of the granitic batholith, which as explained under 'general geology,' is thought to have occurred in Jurassic and probably late Jurassic time.

THE CALLAHAN GROUP.

The Callahan group (Diag. 3), owned by Mrs. Callahan, consists of six claims which adjoin the Laverdiere group on the north and extend in a northerly direction to the upper end of Torres channel, known as West bay. The contact between the Mt. Stevens rocks and the Coast Range intrusives passes through these claims, but is in most places concealed by superficial materials and by forest growth; wherever the contact is exposed, however, ore materials occur in the vicinity much resembling those on the Laverdiere property. These deposits have not been at all developed, the assessment work having been performed on various quartz veins which are generally lens-shaped. These occur mainly in greenish schistose rocks and are prevailingly only a few inches, but in places are as much as 6 feet in thickness; they show generally only a small amount of pyrite, but are claimed to contain also native gold.

COAL.

GENERAL.

No coal in place had been discovered in Atlin mining district to October 1, 1910, but a considerable amount of float and wash coal had been found near the summit of Sloko mountains, at a point to the northeast of and overlooking the lower end of Sloko lake, and a number of claims, generally known as the Sloko Lake claims, were located to cover the supposed coal seams presumed to occur in that locality. The nature of the detrital coal shows that it has come only a short distance, and Tantalus conglomerate (which wherever found in southern Yukon is associated with coal seams), is exposed immediately above the coal float; it, therefore, appears as if a small amount of work should uncover the seams from which the float is derived. As the float and Tantalus conglomerate have been found near the summit of the mountain, the seams when found, unless they can be traced down to lower, more accessible points will not be profitably workable.

Tantalus conglomerate has been found elsewhere in Atlin district, and in all probability coal will yet be found in other places besides in the vicinity of the present Sloko Lake claims.

A seam of coal, 4 feet thick, is reported to occur on Taku river to the south of Atlin mining district.

SLOKO LAKE CLAIMS.

In 1908 Mr. Alex. McDonald was informed by Indians of the occurrence of float-coal near the southeastern summit of Sloko mountains, and at a point to the northeast of and overlooking the lower (east) end of Sloko lake. Since then ten claims have been located in the vicinity by Alex. McDonald, Norman McLeod, James Johnson, M. A. Dickson, J. Dunham, M. Wynn Johnson, David Gibb, E. Lambert, N. C. Wheeling, and Samuel Johnson. Seven of these claims are now owned or controlled by the Amalgamated Development Co. of Vancouver, B.C.

The rocks outcropping along the shores and on the hills overlooking the lower end of Sloko lake from the north are mainly volcanic flows and tuffs and are prevailingly greyish to yellow in colour except where stained by iron oxide. In composition they appear to be largely midway between rhyolites and andesites, and considerable portions of them might thus be designated as latites or latite tuffs. Occasional basaltic dykes pierce these materials but do not comprise any considerable portion of the general formation. The lava flows or beds lie nearly flat and outcrop horizontally along the walls of Sloko Lake valley, giving rise to benches or terraces forming broad steps up the mountain slopes. These rocks weather and decrepitate rapidly, giving rise to an abundance of talus which in turn decomposes readily to form a fine ash-like material. The mountains are consequently, in most places, rugged and precipitous, and the scenery is wild and imposing.

These volcanic rocks extend to the east down the valley of Sloko river, the outlet of Sloko lake, for approximately 2 miles, where sedimentary rocks belonging to the Jura-Cretaceous Laberge series outcrop and thence continue down the valley for several miles at least. The Laberge beds occur also on the mountain slopes on the north side of Sloko river, where they extend to an elevation of 2,550 feet above Sloko lake at their most northwesterly exposure about 2½ miles in a northeasterly direction from the northeastern corner of the lake.[1] There only a narrow tongue of these rocks has been stripped, by erosion and weathering processes, of the original cover of volcanics, and is still surrounded, and overlain on three sides, by flat-lying beds which hide the remaining portions of the Laberge rocks to the north, east, and west.

The sedimentary beds where exposed strike about N. 70° W., dip to the southwest at from 20° to 50°, and consist mainly of dark finely textured shales, sandstones, and greywackes, and also include, near the summit of the ridge, some dark conglomerates that belong to the Tantalus conglomerates, and consist entirely of quartz, chert, and slate pebbles, generally firmly cemented together. All the important coal seams that have been found in northern British Columbia and southern Yukon occur in association with these Tantalus conglomerate beds.

The uppermost portion of this sedimentary area just described is, in most places, covered by several feet of weathered and decomposed material, which is derived from the surrounding and underlying volcanics and sediments, predominantly from the volcanics, and is in the form of sand, mud, and clay; this in places contains a certain amount of wash-coal which occasionally occurs in layers more or less mixed with other products of erosion and weathering, and near the summit of the ridge, pieces of lignitic coal and carbonized wood, as much as 6 inches thick, have been found. Some of the layers of detrital coal were at first thought to be coal seams in place, but they were found on close examination to be float.

When this locality was visited in the latter part of September, 1910, the seams from which the float coal is derived had not been discovered, but it was considered that a small amount of work should expose them. The pieces of coal found are lignitic in character and would make a good fuel. The utilization of this coal, when found in place, will be difficult owing to the fact that it is situated on a mountain-top high above timber-line and in an almost inaccessible portion of the district. An attempt should be made to trace the seams, when discovered, to the more accessible country lying to the east or southeast, in the valleys of Sloko river

[1] The level of Sloko lake on September 25 was approximately 230 feet above that of the upper end of Atlin lake.

or its tributaries, where it might pay to mine the coal if found in clean seams of sufficient thickness.

OTHER COAL.

Coal is to be expected wherever the Tantalus conglomerates occur, especially where any considerable thickness of the beds remains. The south side of the lower end of Sloko lake and the hills along Sloko river are very promising localities and should be carefully prospected.

Tantalus conglomerates were found on an inconspicuous summit on the south side of Graham inlet about 5 miles southwest of Taku Landing, but only about 30 feet of the beds remains, as the overlying portions have been removed by erosion; however, it is probable that more of the conglomerates occur farther to the south and southwest where the accompanying coal seams should also be found. This probability is very much strengthened by the report that small pieces of coal have been found during the past season on one of the creeks running into the north side of Graham inlet.

Further, a piece of solid, firm coal, apparently bituminous in character and weighing possibly 20 or 30 pounds, was brought to Atlin by prospectors, and placed on exhibition in the Gold Commissioner's office. This sample is reported to have been obtained from a 4 foot seam on the Taku river, 12 miles above canoe navigation, and about 30 miles from Juneau.

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CANADA

DEPARTMENT OF MINES

HON. LOUIS CODERRE, MINISTER, A. P. LOW, DEPUTY MINISTER.

GEOLOGICAL SURVEY

R. W. BROCK, DIRECTOR

CLASSIFIED LIST OF RECENT REPORTS OF GEOLOGICAL SURVEY.

Since 1910, reports issued by the Geological Survey have been called memoirs and have been numbered Memoir 1, Memoir 2, etc. Owing to delays incidental to the publishing of reports and their accompanying maps, not all of the reports have been called memoirs, and the memoirs have not been issued in the order of their assigned numbers, and, therefore, the following list has been prepared to prevent any misconceptions arising on this account.

Memoirs and Reports Published During 1910.

REPORTS

Report on a geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont. By W. H. Collins. No. 1059.

Report on the geological position and characteristics of the oil-shale deposits of Canada. By R. W. Ells. No. 1107.

A reconnaissance across the Mackenzie mountains on the Pelly, Ross and Gravel rivers, Yukon and North West Territories. By Joseph Keele. No. 1097.

MEMOIRS—GEOLOGICAL SERIES

Memoir 1. *No. 1, Geological Series.* Geology of the Nipigon Basin, Ontario. By Alfred W. G. Wilson.

Memoir 2. *No. 2, Geological Series.* Geology and ore deposits of Hedley Mining District, British Columbia. By Charles Camsell.

Memoir 3. *No. 3, Geological Series.* Palaeoniscid fishes from the Albert Shales of New Brunswick. By Lawrence M. Lambe.

Memoir 5. *No. 4, Geological Series.* Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district, Yukon Territory. By D. D. Cairnes.

Memoir 6. *No. 5, Geological Series.* Geology of the Haliburton and Bancroft areas, Province of Ontario. By Frank D. Adams and Alfred E. Barlow.

Memoir 7. *No. 6, Geological Series.* Geology of St. Bruno Mountain, Province of Quebec. By John A. Dresser.

MEMOIRS—TOPOGRAPHICAL SERIES.

Memoir 11. *No. 1, Topographical Series.* Triangulation and spirit levelling of Vancouver Island, B.C., 1909. By R. H. Chapman.

Memoirs and Reports Published During 1911.

REPORTS.

Report on a traverse through the southern part of the North West Territories, from Lac Seul to Cat lake, in 1902. By Alfred W. G. Wilson. No. 1006.

Report on a part of the North West Territories drained by the Winisk and Upper Attawapiskat rivers. By W. McInnes. No. 1080.

Report on the geology of an area adjoining the east side of Lake Timiskaming. By Morley E. Wilson. No. 1064.

MEMOIRS—GEOLOGICAL SERIES.

Memoir 4. *No. 7, Geological Series.* Geological reconnaissance along the line of the National Transcontinental railway in western Quebec. By W. J. Wilson.

Memoir 8. *No. 8, Geological Series.* The Edmonton Coal field, Alberta. By D. B. Dowling.

Memoir 9. *No. 9, Geological Series.* Bighorn Coal basin, Alberta. By G. S. Malloch.

Memoir 10. *No. 10, Geological Series.* An instrumental survey of the shorelines of the extinct lakes Algonquin and Nipissing in southwestern Ontario. By J. W. Goldthwait.

Memoir 12. *No. 11, Geological Series.* Insects from the Tertiary lake deposits of the southern interior of British Columbia, collected by Mr. Lawrence M. Lambe, in 1906. By Anton Handlirsch.

Memoir 15. *No. 12, Geological Series.* On a Trenton Echinoderm Fauna at Kirkfield, Ontario. By Frank Springer.

Memoir 16. *No. 13, Geological Series.* The clay and shale deposits of Nova Scotia and portions of New Brunswick. By Heinrich Ries assisted by Joseph Keele.

MEMOIRS—BIOLOGICAL SERIES.

Memoir 14. *No. 1, Biological Series.* New species of shells collected by Mr. John Macoun at Barkley Sound, Vancouver Island, British Columbia. By William H. Dall and Paul Bartsch.

Memoirs Published During 1912.

MEMOIRS—GEOLOGICAL SERIES.

Memoir 13. *No. 14, Geological Series.* Southern Vancouver Island. By Charles H. Clapp.

Memoir 21. *No. 15, Geological Series.* The geology and ore deposits of Phoenix, Boundary District, British Columbia. By O. E. LeRoy.

Memoir 24. *No. 16, Geological Series.* Preliminary report on the clay and shale deposits of the western provinces. By Heinrich Ries and Joseph Keele.

Memoir 27. *No. 17, Geological Series.* Report of the Commission appointed to investigate Turtle Mountain, Frank, Alberta, 1911.

Memoir 28. *No. 18, Geological Series.* The geology of Steeprock lake, Ontario. By Andrew C. Lawson. Notes on fossils from limestone of Steeprock lake, Ontario. By Charles D. Walcott.

Memoirs Published to Date During 1913.

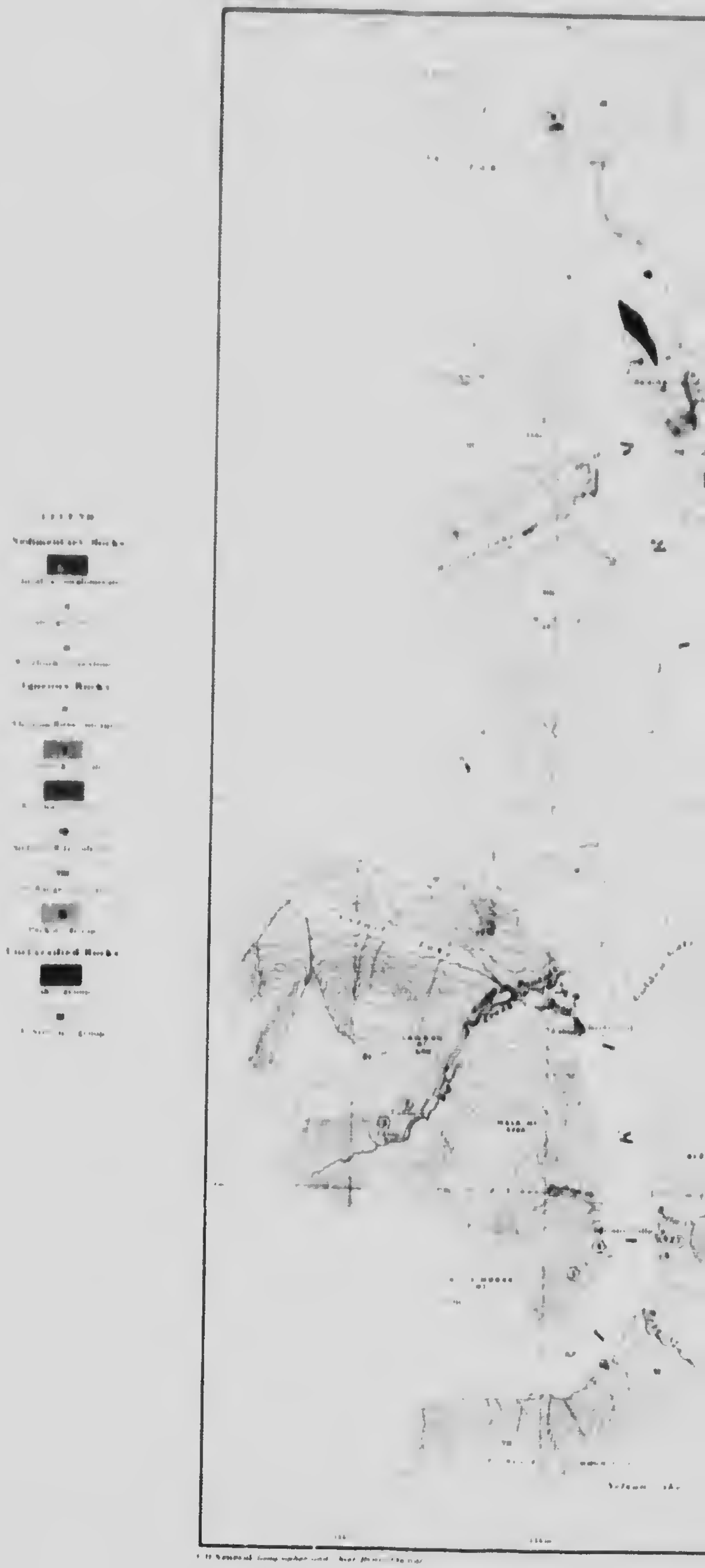
MEMOIRS—GEOLOGICAL SERIES.

Memoir 18. *No. 19, Geological Series.* Bathurst district, New Brunswick. By G. A. Young.

Memoir 13. *No. 20, Geological Series.* Wheaton district, Yukon Territory. By D. D. Cairnes.

Memoir 25. *No. 21, Geological Series.* Clay and Shale Deposits of the Western Provinces (Part II). By Heinrich Ries and Joseph Keele.

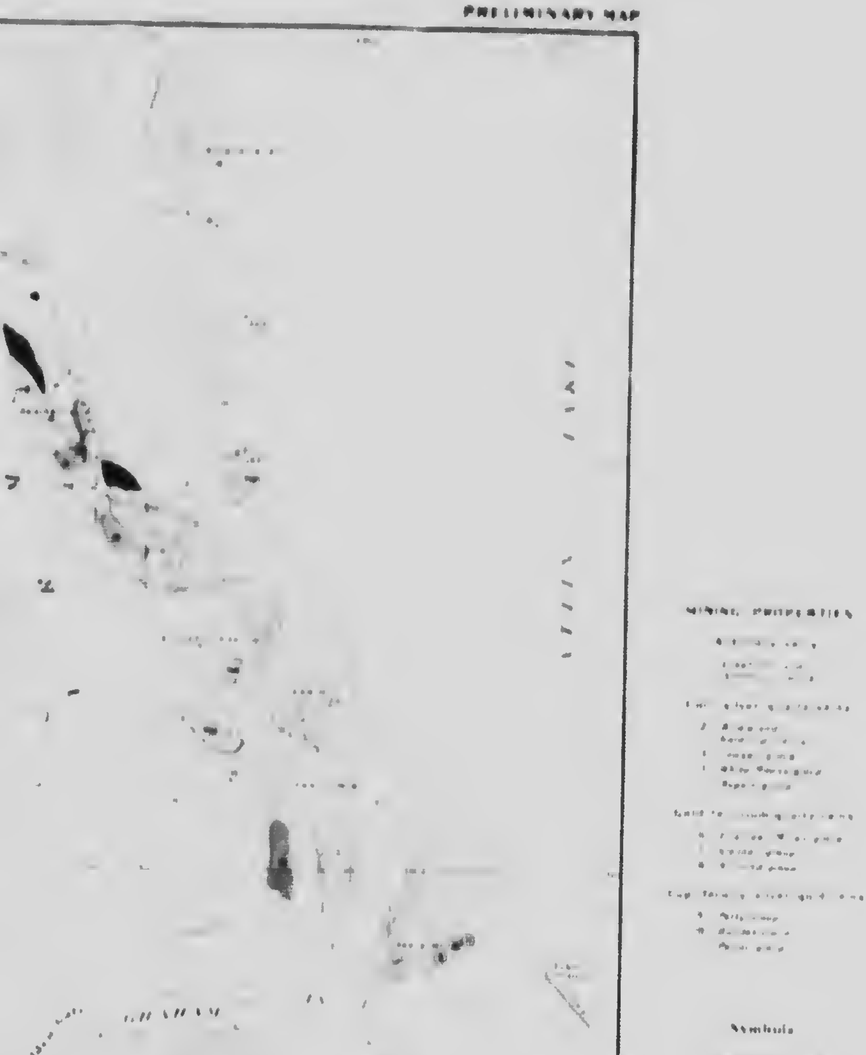
Memoir 37. *No. 22, Geological Series.* Portions of Atlin district, B.C. By D. D. Cairnes.



TAKU ARM, ATLIN

Canada
Department of Mines

PRELIMINARY MAP



MAP 94A
Issued 1911

..., ATLIN DISTRICT, B.C.

Scale of miles