CANADA

DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY

W. H. COLLINS, DIRECTOR

MEMOIR 150

No. 131, GEOLOGICAL SERIES

# Whitehorse District, Yukon

BY

W. E. Cockfield and A. H. Bell

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

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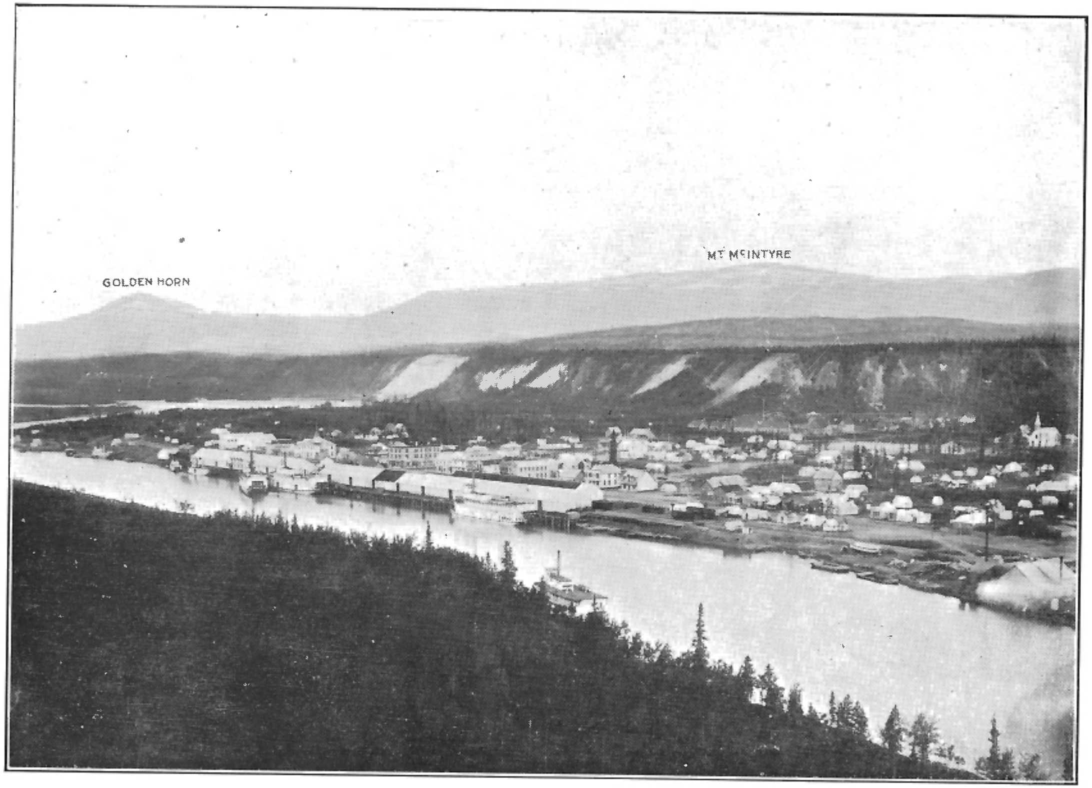


Town of Whitehorse.

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## Illustrations

# Whitehorse District, Yukon

## CHAPTER I

## INTRODUCTION

The importance of the Coast Range batholith in the genesis of ore deposits has long been recognized in British Columbia and in Yukon. The work of several earlier investigators in southern Yukon along the eastern margin of the batholith had resulted in maps of isolated areas. In 1922 it was decided to make a reconnaissance map of a large area, that would link up the work already done along the eastern margin of the batholith. The area selected lies between latitudes 60 and 61 degrees north and longitudes 134 and 136 degrees west. This area was chosen largely because many parts of it have easy access to railway transportation and, therefore, should offer good ground for prospecting. Owing to the size of the area none of the ground examined by earlier investigators was gone over, and the western half of the area was completed in 1922. In 1923 work on the eastern part of the area was commenced and in the early part of 1924 was completed. This report, therefore, is a compilation including the work of earlier investigators and the results obtained during the field seasons of 1922, 1923, and 1924. The eastern part of the area, mapped by A. H. Bell in 1923, formed the subject of a doctorate thesis at the University of Chicago, and the thesis is incorporated in this report.


## ACKNOWLEDGMENTS

Able assistance in the field during 1922 was rendered by Messrs. N. T. Ellis, T. D. Guernsey, and R. H. B. Jones; during 1923 by Messrs. N. T. Ellis, C. H. Stockwell, and C. S. Evans; and in 1924 by Messrs. C. H. Stockwell, B. B. Brock, and S. Gibson.


## PREVIOUS WORK

Considerable work has been done in parts of Whitehorse district and adjacent areas. In 1887 G. M. Dawson[1] carried out a reconnaissance traverse through Yukon territory. In September of that year he passed through Whitehorse district in eight days, travelling by boat along lake Laberge, Lewes river, Marsh lake, Tagish lake, and lake Bennett. During this brief time he obtained a surprising amount of information about the geology of the region. The years 1895 to 1898 saw the influx of great numbers of gold seekers to the Klondike, and their route lay along the main waterways of Whitehorse district. Some of those who passed through were attracted by the indications of mineral deposits, and owing to their efforts mining development was begun. In 1901 J. C. Gwillim[2] worked in Atlin district, British Columbia, the area adjacent to Whitehorse district on the south. In 1906 Cairnes[3] worked in Conrad and Whitehorse districts.

[1] Dawson, G. M.: "Report on an Exploration of Yukon District, N.W.T."; Geol. Surv., Canada (1887).
[2] "Report on Atlin Mining District"; Geol. Surv., Canada, Ann. Rept., vol. XII, pt. B (1899).
[3] Cairnes, D. D.: "Portions of Conrad and Whitehorse Mining Districts"; Geol. Surv., Canada (1908).

In 1909 McConnell[1] reported on the copper deposits in the vicinity of Whitehorse and in 1909 and 1915 Cairnes[2] did further work in Wheaton district.

## FIELD METHODS

To complete the map accompanying this report a system of triangulation was rapidly extended over the area simultaneously with the general mapping. The base-lines were tied to points previously located. By means of intersections from triangulation stations and intermediate plane-table stations located by resection, the major physical features were sketched with a minimum amount of traversing. The type of country mapped is specially suited to this method of work.

## CLIMATE

The climate of southern Yukon is by no means as severe as is quite generally believed. The winters, on account of the northern latitude are, of course, rigorous, but not unduly so, and although extremely low temperatures do occur, they do not as a rule continue for long periods of time. The summers, on the other hand, are peculiarly delightful, as on account of the northern latitude continuous daylight prevails during parts of May, June, and July, and for four months warm summer weather is experienced. The rivers open early in May, and remain open until well on into October or even November, but the ice remains in the larger lakes until the first week in June. Slack water freezes over any time after the middle of October.

## FOREST GROWTH

The forest growth of southern Yukon is rather sparse. Trees grow chiefly in the valley bottoms, but also extend up the hill-sides to an elevation of 4,000 feet above sea-level. The upper slopes and the entire plateau surface are devoid of forest growth, as are some of the higher valleys of the district. Eight species attain the dimensions of trees; of these white spruce is the most widely distributed. It grows most plentifully on the valley flats where the individual trees seldom exceed 12 inches in diameter. This tree forms the most useful member for mining and general constructional purposes, being strong and readily worked. Balsam fir is next in importance to white spruce and supplies a fair grade of timber. The average of this species rarely exceeds 10 inches in diameter. Trees of this variety are plentiful on the mountain slopes.

Black spruce occurs associated with white spruce, but rarely attains a workable size. Black pine occurs most plentifully along sandy benches, but the stumps are seldom more than 10 inches thick. White birch is rare and is never of large size; aspen poplar and balsam poplar are plentiful, particularly along the alluvial flats of the main valleys.

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[1] McConnell, R. G.: "Whitehorse Copper Belt"; Geol. Surv., Canada (1909).
[2] Cairnes, D. D.: Geol. Surv., Canada, Mem. 31 (1912). Geol. Surv., Canada, Sum. Rept. 1915, pp. 36 to 49.

# CHAPTER II

## TOPOGRAPHY

Yukon territory includes parts of three major physiographic provinces, the Coast Range, Yukon Plateau, and the Mackenzie Mountains provinces.

The Coast range, with a general northwest trend, follows the Pacific coast from southern British Columbia to near the head of Lynn canal. At this point it turns inland, and forms the innermost member of a series of ranges, until it finally merges with Yukon plateau, in the vicinity of lake Kluane.

The Yukon plateau is a northern member of the series of plateaux that stretch through British Columbia, Yukon, and Alaska to Bering sea. It is flanked on the west by the Coast range and on the east by the mountains of the Mackenzie system.

The Mackenzie Mountain system forms the height of land between the Yukon and Mackenzie River basins. It trends northwest and west across Yukon and Alaska towards Bering sea.

Whitehorse district lies partly within the Coast Range province and partly within the Yukon Plateau province. The line of demarcation between the two provinces is nowhere very definite, but a line drawn north-northwest from Windy arm through the western part of Wheaton district and down the valley of Ibex river roughly marks the division between the two. West of this line granitic intrusives predominate; east of it they are subordinate. In other words the Coast range coincides very closely with the area underlain by the granitic batholith.

### THE COAST RANGE

The Coast range consists of a complex of peaks and mountain masses that have little symmetry of arrangement other than a rough alignment along the northwesterly-trending axis of the range. The aspect of the range is precipitous and rugged in the extreme, common forms being jagged, needle-like, or saw-toothed peaks with knife-edged ridges and sharply incised valleys (*See* Plates I and V). The peaks rise from 6,000 to 8,000 feet above sea-level,[1] whereas in southern British Columbia they attain heights of from 8,000 to 9,000 feet.

### THE YUKON PLATEAU

Throughout Whitehorse district to the east of the Coast range there are somewhat extensive remnants of what appears to have been an ancient peneplain that has later been uplifted and dissected. This is the Yukon plateau, a gently undulating upland which is best viewed from a summit at or near the elevation of the plateau surface. From such a point the observer is struck by the nearly level character of the upland sweeping

[1] All elevations in this report are referred to sea-level.

away in all directions to the horizon and broken only here and there by isolated residual masses that rise above the general level. This horizontal surface might in places be taken for a surface of construction, but it is readily seen that it truncates alike rocks of widely varying degrees of resistance. The upland stands at an average elevation of 5,000 feet.

Into this upland surface the streams have cut valleys ranging from 1,500 to 4,000 feet in depth. A pronounced topographic unconformity exists along the boundaries of the steep-sided valleys which dissect the peneplained surface and in the eastern half of Whitehorse district divide it into several more or less distinct units bounded by the deep valleys occupied by Lewes river and the long, narrow lakes, lake Bennett, Windy arm, Tagish lake, Taku arm, and Marsh lake. One of these is the region east of lake Bennett and south of Tagish lake where the topography is characterized by numerous, rugged peaks, the higher ones reaching an elevation of 7,500 feet. This region has been described by Cairnes.[1] A second of these units is the region enclosed by Watson River valley, Tagish lake, Marsh lake, and Lewes river. In this area there are three outstanding peaks, mounts Lorne (6,610 feet), Lansdowne (5,849 feet), and Caribou (6,423 feet). Though these individual peaks reach heights comparable with those in the adjacent part of the Coast range, there is a greater proportion of lowland area in this region than in the Coast Range province, and, therefore, the average elevation is considerably less. Remains of an uplifted peneplain at elevations from 5,000 to 5,500 feet may be distinguished in the vicinity of the higher peaks. A third region is that east of Marsh lake and northeast of Lewes river. The greater part of this area is drained by McClintock river and its tributaries. The topography is dominated by a number of parallel ridges, in general rising toward the north and culminating in such peaks as mount Juno (6,836 feet) and mount Byng (6,763 feet). The proportion of lowland to upland area is similar to that in the division last described and considerably greater than that typical of the Coast Range province.

## GLACIATION

The effect of glacial action on the topography is patent to the most casual observer. U-shaped valleys (Plates III and V), truncated spurs (Plate III), and hanging valleys are the most conspicuous effects visible from a distance. Only slightly less evident is the aggradational effect of the ice action. Morainal deposits are common (Plate VI B), and are prominent in some of the wider valleys where the "knob and kettle" topography, typical of the ground moraine, occurs. Roches moutonées occur in many places and—along with them—smoothed, polished, and striated rock surfaces.

The direction of the latest ice movement, as indicated by these grooves and striæ, is parallel to the main valleys, and it is assumed that the movement was in general in the direction of the modern drainage, namely, northwest. Well-preserved striæ and grooves are common at elevations of from 5,000 to 5,500 feet, and examples were observed near mount Juno

[1] Cairnes, D. D.: "Conrad and Whitehorse Mining Districts"; Geol. Surv., Canada (1908).

at 5,940 feet. Rapid erosion of the isolated highest peaks such as mounts Juno and Byng would account for the absence of any striæ that might once have been on their highest parts. Cairnes held that in Wheaton district glacial movement was confined to the valleys and that the upland surfaces were affected by nivation. The presence of grooves and striæ at the heights noted above seems to call for a modification of this view and it is thought probable that little if any of the land surface of Whitehorse district escaped the effects of active glacial motion, although on the whole the glacial action was of the valley rather than the continental type.

## DRAINAGE

Whitehorse district is drained entirely by Lewes river and its tributaries, chief among these being Takhini, Watson, Wheaton, and McClintock rivers. Lewes river is navigable by large river steamers as far up as Whitehorse, a short distance above which Whitehorse rapids and Miles canyon form an obstacle to navigation. The rapids are caused by a basalt flow that dammed the river, probably in Quaternary time. From lake Bennett to lake Laberge, Lewes river occupies a valley from 4 to 10 miles wide and flanked by mountains that rise up to 3,000 feet above the river. The central part of this large valley is floored with silts and boulder clays through which the Lewes has cut a narrow, winding, secondary valley about 200 feet wide.

An inspection of the map suggests certain rather obvious changes that may have taken place. Lewes river may have flowed through the lower part of the valley of Watson river instead of around by lake Bennett (following the present route of White Pass and Yukon railway). Certainly this part of Watson valley is far too large to have been made by the stream which now occupies it. Wheaton river may have followed its same course above Big Bend and here turned to the left instead of to the right, flowing northward through the valley now occupied by Annie lake. Changes in drainage courses such as these were due perhaps, to one or both of two factors: (1) deposition of glacial materials in the former valleys and (2) diastrophic movements.

Over the western half of Whitehorse district, and in Wheaton district in particular, there appears to be remarkably little relation between stream courses and the distribution of rock formations. It may, therefore, be said that here there is a small degree of structural adjustment. East of Lewes river, on the other hand, the map shows a considerable degree of structural adjustment, due to the greater prevalence eastwards of steeply dipping, stratified rocks.

The structural control of drainage courses and the effect of rock structure upon topography in Whitehorse district are questions which have not been dealt with at length by former writers. Cairnes[1] states that the present course of Yukon river marks the axis of the Yukon plateau, towards which there is a gradual slope both from the east and the west, and that this was caused by differential uplift. It seems probable that a number of the larger valleys in Whitehorse district likewise had their

[1] Cairnes, D. D.: "Wheaton District"; Geol. Surv., Canada, Mem. 31, pp. 84 (1912).

position determined to a great extent by structural factors. The parallelism of the strike of the steeply dipping beds of the Laberge series to Marsh lake, Watson River valley, etc., and to the Coast range, supports this view. The drainage pattern of McClintock basin has a rather striking rectangular effect, again suggesting structural control of drainage. Teslin river, which crosses the northwest corner of Whitehorse district, has a course that departs very little from a straight line for nearly 100 miles. Its direction is here parallel to the Coast range.

# CHAPTER III

# GENERAL GEOLOGY

## INTRODUCTION

A great variety of rocks, both sedimentary and igneous and ranging in age from Precambrian to Recent, outcrop in Whitehorse district. A series of highly metamorphosed rocks is supposed to be of Precambrian age. The Palæozoic is represented chiefly by a thick series of slates, "cherty quartzite," and limestone. Great amounts of bedded tuff and conglomerate with interbedded marine shale were laid down in Mesozoic time. Fossils from the shales indicate that their age ranges from Middle Lias to Lower Inferior Oolite. These and the older rocks were intruded in late Jurassic and possibly early Cretaceous time by the granodioritic rocks of the Coast Range batholith. This was the geologic event of paramount importance in the region. To it is ascribed the origin of all the ore deposits of Whitehorse district, varied as they are in mineral association, texture, and occurrence. The Tertiary history of the region is largely one of igneous activity; sedimentary strata with organic remains by means of which events might be dated appear to be totally lacking.

*Table of Formations*

| Era | Period | Formation | Lithological character |
|---|---|---|---|
| Quaternary | | Superficial deposits. | Gravel, sand, boulder clay, silt, muck, morainal materials, volcanic ash, soil |
| Tertiary | | Acid volcanics...... | Rhyolite, granite porphyry, and related volcanics, with associated tuffs and breccias |
| | | Newer volcanics.... | Andesite, basalt, and related dyke rocks, with associated tuffs and breccias |
| Mesozoic | Upper Jurassic or later | Coast Range intrusives | Granitic rocks ranging in composition from granite to diorite, with associated porphyritic phases |
| | | Older volcanics..... | Andesite, diabase, basalt, and related volcanics with associated tuffs and breccias |
| | Lower and Middle Jurassic | Tantalus conglomerate | Conglomerate, with sandstone, shale, and seams of coal |
| | | Laberge series...... | Argillite, shale, sandstone, arkose, greywacke, tuff, conglomerate |
| Palæozoic | Triassic (or, and) Carboniferous (?) | Limestone.......... | Limestone, more or less dolomitic |
| | Devonian (?) | Taku group......... | Slates, cherty quartzite, etc. |
| | | Gold series (?)...... | Pyroxenite, peridotite |
| Precambrian (?) | | Mount Stevens group | Sericite and chlorite schist, mashed basic to semi-basic volcanics, gneissoid quartzite, hornblende gneiss, and limestone |

# DESCRIPTION OF FORMATIONS

## Mount Stevens Group

The Mount Stevens group includes a number of members widely different in appearance, composition, and possibly in age. They are, however, all old and so extremely altered that their mode of origin and succession are obscured. They consist of sericite and chlorite schists, greenstone schists, sericitic quartzites, gneissoid quartzites, hornblende gneisses, and crystalline limestone.

These rocks are extensively developed in the western part of the district, but do not occur in the eastern part. In Wheaton district, as mapped by Cairnes, they form a single belt about ½ to 1 mile wide and extending 10 miles from Tally-ho mountain to mount Hodnett. They also occur on Stevens mountain and Dickson hill, and in many other places small patches are present. To the west of Wheaton district these rocks are extensively developed in the vicinity of the Devils Thumb, Primrose river, and Mud lake.

### LITHOLOGICAL CHARACTERS

The members of the Mount Stevens group consist of sericite schists, chlorite schists, greenstone schists, sericitic quartzites, gneissoid quartzites, hornblende gneisses, and crystalline limestone.

#### *Sericite Schists*

These are light grey, soft, fissile rocks of a bright, glistening appearance due to the amount of mica they contain. Under the microscope they are seen to consist mainly of quartz and sericite, but hold also some orthoclase, plagioclase, and secondary calcite. The original feldspars have been for the most part alkali feldspar and have been replaced by sericite and calcite. The rocks appear to have been rhyolite-breccias that have been metamorphosed into sericite schists.

#### *Chlorite Schists*

The chlorite schists are pale to dark green, soft, friable rocks, occasionally with a reddish cast due to the presence of limonite. Microscopically these rocks are seen to be composed chiefly of calcite and chlorite, with a considerable amount of iron. It is thought that they are derived from somewhat basic materials.

#### *Greenstone Schists*

This term was adopted by Cairnes to include schistose rocks that have the appearance of mashed diabases, andesites, and related rocks. They form a class distinct from the sericite and chlorite schists. Megascopically they are fine to medium-textured, greenish rocks, and are prevailingly firm and compact. They always have a laminated structure. Under the microscope several types are distinguishable. The greenstone schists of mount Stevens appear to be mashed andesites consisting chiefly of plagioclase, considerable chlorite, with some calcite, quartz, and iron ores.

Remnants of a porphyritic texture have been preserved in which large plagioclase phenocrysts are prominent. The greenstone schists of Hodnett mountain have also a porphyritic texture. Large particles of plagioclase and augite occur, as well as considerable amounts of zoisite, chlorite, and accessory iron ores. The rocks have probably originally been andesites.

Similar types occur on Tally-ho mountain.

### *Sericitic Quartzites*

Sericitic quartzites in the vicinity of Gold hill and along Primrose river are dark greenish, fine-grained rocks with close foliation, and are of sedimentary origin.

### *Gneissoid Quartzites*

Gneissoid quartzites occur near the summit of mount Anderson in Wheaton district and also along Primrose river to the west of Wheaton district. They are prevailingly light grey to white, with a common development of colour banding. The rocks have a fine, gneissoid structure and to the eye appear to consist entirely of quartz. Under the microscope they are seen to consist of grains of quartz intergrown with feldspar, which is much altered to sericite and calcite; numerous shreds of biotite also occur.

### *Hornblende Gneisses*

The hornblende gneisses are fine to coarse-textured rocks with a decided gneissoid structure. They have the appearance of crushed basic to semi-basic intrusives. Under the microscope they show varying amounts of plagioclase, quartz, and hornblende. Augite is also present. These rocks have probably been derived from gabbros and granodiorites.

### *Limestone*

The limestones vary from white to slate and can generally be distinguished from a long distance by their colour. They are somewhat argillaceous or more commonly siliceous, and occur generally in heavy, massive beds.

## AGE AND CORRELATION

No fossils have been collected from any of the members of the Mount Stevens group and there is consequently no direct evidence as to their age, but from the evidence afforded by the later igneous rocks which cut them they are in all probability the oldest rocks of the district. In other districts similar schistose rocks were classed as pre-Devonian or pre-Carboniferous, according to the determined age of the lowest fossiliferous strata. Cairnes[1] in his later work along the International Boundary, north of Yukon river, was able to demonstrate that the schistose rocks of that region were pre-Middle Cambrian and in all probability Precambrian in age. He considered that various developments of schistose rocks in Yukon basin were probably also Precambrian and, therefore, members of the Yukon group, to which he also assigned the Mount Stevens group, although admitting that there might be some doubt as to the accuracy of the correlation.

[1] Cairnes, D.D.: "Yukon-Alaska International Boundary"; Geol. Surv., Canada, Mem. 67, pp. 40-44 (1914).

The Mount Stevens group in this report has been provisionally assigned to the Precambrian, but it must be borne in mind that some doubt exists as to the accuracy of this correlation. Further, as the group includes metamorphosed igneous rocks and also sediments of varied characters, the members of the group may represent widely different time stages of the Precambrian or even of the Palæozoic.

## Gold Series (?)

### *Pyroxenite and Peridotite*

Pyroxenite and peridotite occur at a number of localities in Whitehorse district, but in only two of these do they occupy an area large enough to be shown on the accompanying map (No. 2071). One of these occurrences is on the south slope of mount Tally-Ho, in Wheaton district. The other is on Red ridge, about 8 miles north of mount Michie. Here, an elongated, dome-shaped hill, with a trend somewhat east of north, and parallel to the Coast range, appears to be wholly made up of pyroxenite, peridotite, and related rocks. Its summit reaches an elevation of over 5,000 feet, or about 2,000 feet above the adjacent valleys. The characteristic reddish-brown weathering of its rocks makes it conspicuous from afar. In this respect it resembles the Brown Dome of Atlin district, described by Gwillim. A comparison shows that the rocks from these two rather widely separated areas are strikingly similar in mineral composition and association. It is noteworthy that they have a similar position with reference to the Coast range.

Associated with these basic rocks on Red ridge are numerous veins filled with serpentine and, in some cases, coarsely crystalline amphibole. A large vein of the amphibole has a width of 4 inches, is very straight, and has a strike of north 85 degrees east magnetic and a nearly vertical dip. A fault cutting it at nearly a right angle has produced a displacement in the horizontal direction of 30 feet. Numerous other veins were noted, chiefly of massive serpentine, and some with associated talc and magnesite. The serpentine is dark olive-green with a waxy lustre and a pale brown coating of weathered products. Some serpentine veins have central veins of chrysotile asbestos. The longest fibres seen had a length of about $\frac{3}{16}$ inch. It is possible that veins exist in this locality having fibres long enough to be of economic value. Fibrous serpentine and talc occur in narrow fissures throughout the rock and on surfaces which appear to be slickensided.

The rock as a whole is very massive and no major structural features were noted except jointing and faulting, neither of which is very prominent. Fresh surfaces in some cases appear coarse-grained granular, and in others no granular texture is visible. The rock is medium to dark grey or black, with, in places, a greenish tinge. Where the general colour is medium grey it is mostly coarsely mottled with spots of a darker colour, and exhibits occasional cleavage faces of a dark mineral. The weathered surface is coarsely pitted and has a bright reddish-brown colour due to the presence of iron oxide.

Under the microscope the texture of the basic rocks was seen to be hypidiomorphic granular and rather coarse grained. In one section the rock contains about 80 per cent olivine, in another, over 95 per cent. Chromite is prominent as an accessory, probably making up 2 per cent of the rock. The rock lower in olivine contains about 20 per cent of a brownish mineral with a high index of refraction (but less than that of olivine) and a good cleavage in one direction. It was so much altered that its extinction angle could not be determined, but it is probably an altered orthorhombic pyroxene. Serpentine is an important alteration product. In one section it exhibits the characteristic texture like the meshes of a net, showing that it has been derived from olivine. It has a yellowish colour in ordinary light and much of it is in veinlets with very fine parallel fibres running crosswise. It exhibits unusually low interference colours. Magnetite occurs in fine grains. There are also aggregates of talc and serpentine with interfingering fibres. In one section the olivine is considerably less altered to serpentine than in the other. It has a fairly well-developed cleavage in one direction and something very like polysynthetic twinning was observed parallel to this in one of the grains. Finely powdered rock was treated with dilute hydrochloric acid and on standing gave gelatinous silica. This proved the mineral to be olivine.

The contacts of these rocks with other formations was not seen. The peridotites may be intrusives or extrusives. Cairnes[1] states that similar rocks in Wheaton district cut members of the Mount Stevens group. "No other definite information was obtained in the district concerning the age of these rocks, but from their lithologic similarity to rocks in other parts of Yukon and in northern British Columbia, they are thought to be probably of about Devonian age."

## Taku Group

The name Taku group was proposed by Cairnes[2] for a series of cherts, slates, and cherty quartzites which have been referred to the Cache Creek group of the southern interior of British Columbia. In Whitehorse district these rocks occur principally in the vicinity of Tagish lake.

The cherty quartzites are thinly bedded, grey or light-coloured rocks, except where iron-stained, when they have a red, weathered surface. The slates are finely bedded, possess the typical slaty structure, cleaving quite readily along the foliation planes, and are in places much folded and disturbed. They grade into quartzites that vary from finely bedded to massive. The cherts are light and dark grey to black, but in places are reddish on weathered surfaces. They are hard, massive, brittle, and break into sharp, irregular fragments. The origin of the cherts is not definitely known. Cairnes supposes them to be largely of sedimentary origin, but Gwillim[3], on the other hand, shows that some at least are pyroclastics of the character of halleflinta.

[1] Cairnes, D. D.: "Wheaton District"; Geol. Surv., Canada, Sum. Rept. 1915, p. 41.
[2] Cairnes, D. D.: Geol. Surv., Canada, Mem. 37, pp. 52-53 (1913).
[3] Gwillim, J. C.: "Report on Atlin Mining District"; Geol. Surv., Canada, Ann. Rept., vol. XII, pt. B, p. 17 (1899).

### AGE

The rocks of the Taku group underlie limestones of Carboniferous (?) age, have been referred to the Lower Cache Creek series, and, therefore, have been considered as probably Devonian in age. This correlation, made largely upon the basis of lithological similarity, is open to question, and the name Taku group was, therefore, proposed by Cairnes.

## Limestone

Large masses of relatively pure limestone are of common occurrence in Whitehorse district. Many ranges of hills in various parts of the area are made up wholly or partly of limestone. The largest and most continuous area is near the southeast corner of Whitehorse district and comprises upwards of 200 square miles in the vicinity of Taku arm, Windy arm, and Tagish lake. Some of the smaller limestone areas shown on the map are: (1) along the lower part of Wheaton River valley; (2) along the east flank of Grey ridge; (3) from about 5 miles north of mount Lorne nearly to Lewes river; (4) east of Marsh lake; (5) in the Whitehorse copper belt. The striking whiteness of the limestone hills in direct sunlight renders them conspicuous features of the landscape.

The limestones are generally pure carbonate, and are then coarsely crystalline; where they contain impurities such as argillaceous matter they are fine-grained and cryptocrystalline. Their usual colour is a light grey, but it varies from almost white to medium grey with, in some cases, a bluish cast. In some places evidence of bedding is absent or obscure. Where present the strike and dip in places show rapid changes within a short distance. However, in some cases the strike remains fairly constant over a considerable area, for example at Canyon mountain east of Lewes river near Whitehorse, where the strike is north-northwest, parallel to the trend of the range. In the area north of mount Lorne, at one locality the strike is north 82 degrees east magnetic and the dip 37 degrees north; at another locality the strike is north 55 degrees west magnetic and the dip 10 degrees northeast. The strike here nearly parallels the adjacent part of Lewes River valley. East of Marsh lake and 5 miles south of mount Michie is a series of low, rounded hills of limestone which are fine-grained, grey, and massive, with occasionally a suggestion of bedding. At one point what appear to be bedding planes strike north 65 degrees east magnetic and dip 65 degrees south. The strike is here parallel to the trend of the belt of limestone. At a point 5 miles east and 1½ miles south of mount Byng, at a contact of limestone with bedded tuff of the Laberge series the limestone appears massive, but a possible bedding plane strikes north 5 degrees east magnetic and dips vertically. An erosional unconformity is indicated between the limestone and the tuff if this be a bedding plane, because it is cut by the surface of contact.

The limestone and cherty quartzite of Atlin district, British Columbia, have been described by J. C. Gwillim and D. D. Cairnes. The following quotation from Cairnes' memoir is descriptive of the limestones.

"These limestones are generally fine 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 only in rare instances are definite bedding planes distinguishable."

G. M. Dawson collected specimens of *Fusulina* from limestone on the west shore of Windy arm and on this basis placed the limestone in the Carboniferous system. He correlated both the limestones and the underlying cherty quartzites, slates, etc., with the Cache Creek group of the southern interior of British Columbia. *Fusulinæ* have not been found at other localities in Whitehorse district.

In certain localities the limestones appear to be devoid of fossil remains. In this class is the limestone area north of mount Lorne and south of Lewes river. The limestone hill to the north of Tagish lake and east of mount Nares was seen to contain some obscure remains of organisms. In the locality east of Marsh lake and 5 miles south of mount Michie fossils are abundant but poorly preserved. Favositoid corals are common and crinoid stems are numerous. Many fragmentary shells, presumably of brachiopods, were seen in section on a smooth, eroded surface. About one mile to the west, in a small, isolated outcrop, the limestone contains closely packed specimens of a thick-shelled brachiopod which could be broken out of the rock with ease. Some of the best specimens collected were submitted to Mr. E. M. Kindle, who states that "the brachiopod has some resemblance to *Newberryia laevis*, but does not represent that species." He is inclined to think that it belongs to a Devonian fauna.

In a small area 1½ miles north of Mount Michie fossil remains appear on the weathered surface of a fine-grained, grey, massive limestone. Sectioned shells of bivalves and gastropods are the most abundant, and some forms resembling bryozoans are present.

Five miles north of the mouth of McClintock river fossils were seen on a smooth, glaciated surface of fine-grained, grey, cryptocrystalline limestone outcropping high up on the hills to the west of the river. Compound corals with individuals radiating outwards from a centre occur in masses from 6 inches to 1 foot in diameter. Rugose corals up to 1 inch in diameter were seen in section only.

The most extensive development of limestone north of Taku Arm area is in the series of rounded hills trending a little west of north from the eastern boundary of Lewes River valley in the vicinity of Whitehorse to lake Laberge. A cursory examination of some of these limestones along the creek flowing northwest from mount Juno proved them to be highly fossiliferous. At an outcrop 5 miles west and 2½ miles north of mount Juno rugose corals and favositoid corals were seen in section on a weathered surface. Farther down stream abundant fragmentary remains were seen of pelecypods, brachiopods, corals, and bryozoans.

From a limestone outcrop about 4 miles south and 1 mile east of mount Cap a fossil compound coral was collected which Mr. E. M. Kindle considers to be probably *Isastrea* of Triassic age. The limestone here is apparently interbedded with a massive, coarse-grained tuff. The dip of both the limestone and tuff is from 20 degrees to 30 degrees to the southwest.

In the western part of Whitehorse district, in the region of the Coast range, limestone is areally of comparatively little importance. Narrow belts of limestone occur in the vicinity of Ibex river. The following is a statement by Mr. Kindle concerning a collection of fossils from this locality.

"The collection made by Mr. W. E. Cockfield, 9 miles below the forks of Ibex river, Yukon territory, represents fossils of a very fragmentary character in an indurated limestone. Among these fragments are one or two crinoid column sections, two pelecypods, and two gastropods, belonging probably to the genera Murchisonia and Natica. One of the pelecypods has strong, angular, post-umbonal ridges and hinge-plate of unusual character. In no case is the material adequate for generic determination and no definite statement concerning its horizon can be made. This unsatisfactory material gives the general impression that it is of Triassic age."

The evidence as to the age of the limestones is unsatisfactory. If it be assumed that the limestones in various parts of Whitehorse district are contemporaneous then the evidence is decidedly conflicting. It is, however, quite possible that limestones belonging to more than one geologic period have been included. Metamorphism has largely operated to obscure the structure; in some places bedding planes have been totally obliterated, and in some cases the limestone has an exceedingly limited areal development, added to which fossil remains are extremely scarce and those individuals found are in many cases too poorly preserved for identification. The most definite evidence to date is the finding of the genus *fusulina* by G. M. Dawson, which would demonstrate that part at least of the limestone is Carboniferous. Some evidence has been presented to show that Devonian and Triassic faunas may also be represented, but as yet no progress has been made in subdividing the limestone into different formations. The evidence as a whole is too meagre to permit of stating that the Devonian and Triassic are represented. Consequently, the various limestones have been included under one colour on the map, with the exception of those limestones included in the Mount Stevens group, and have been referred to the Carboniferous, although it is recognized that both Devonian and Triassic may be included.

## Laberge Series

The rocks included under this head are extensively developed in the eastern half of Whitehorse district, where they occupy a greater area than any other formation except deposits of Pleistocene and Recent age. They occur in long, somewhat narrow belts with a trend a little east of north and south of west, parallel to that of the Coast range. They are not so prominent in the western part of Whitehorse district, although they occupy a

in Bennett area, trend N-NW. but still parallel Coast Range.

considerable area in the vicinity of mount Granger and Fish lake and reach as far west as longitude 135° 35′ west. Their thickness amounts to several thousand feet and has been determined by D. D. Cairnes in the northern part of Wheaton district as being between 5,000 and 6,000 feet. They consist dominantly of volcanic clastics, tuffs, breccias, and conglomerates. Interbedded with the tuffs are considerable thicknesses of marine shales and argillites in which tufaceous material is an important constituent. In a few places thin beds of dark, impure limestone are interbedded with the bedded tuffs.

The Tantalus conglomerates have been included with the Laberge series on Map 2071 accompanying the present report. In his report on the Conrad and Whitehorse mining districts Cairnes groups the two formations under the name Tutshi series.

In spite of the fact that the Laberge series is the most widely occurring formation in the eastern half of Whitehorse district, it was not possible in the limited time available for field work to establish a definite stratigraphic succession. The similarity between beds of widely differing horizons, the scarcity of fossils, and the obscurity of the structural relations were factors that contributed to this result. Another important factor is that the Laberge series is essentially of volcanic origin, and, therefore, it is to be expected that the strata thicken and thin somewhat rapidly.

No definite statement can be made regarding the total thickness of the series. In Wheaton district, according to D. D. Cairnes, it is between 5,000 and 6,000 feet. The field evidence points to a possibly greater thickness farther east. In many places in the eastern half of Whitehorse district the rapid variations in strike and dip of the beds render any measurement of thickness extremely difficult. In a few places, however, the strike and dip are comparatively constant. A section across the southern end of the ridge, about 4 miles east of mount Lorne, where the dips are fairly constant for about 2 miles in a direction at right angles to the strike, gives a thickness of approximately 10,000 feet, but this result is based on the assumption that the dip and strike remain constant across an intermediate drift-covered area half a mile wide, and that there is no repetition due to folding or faulting, or both. On the other hand, there is the possibility that not all of the Laberge series strata have been included.

In Wheaton district, where the most detailed work done in the district was undertaken, and where the best exposures of typically marine sediments occur, Cairnes[1] recognized a threefold division of the Laberge beds as follows, or if, as in the present case, the Tantalus conglomerate be included, a fourfold division:

Tantalus conglomerate: thickness 1,800 feet. Conglomerate, shale, sandstone, and coal

Laberge series: Upper beds: thickness 1,500 feet, chiefly sandstone
Middle beds: thickness 1,700 feet, shales, sandstone, arkose
Lower beds: thickness 1,800 feet, arkoses and tuffs with shales and conglomerates

Cairnes notes that these divisions are only approximate and that the thickness of each varies. In the lower beds the arkoses are generally light

[1] Cairnes, D.D.: "Wheaton District"; Geol. Surv., Canada, Mem. 31, pp. 54–56 (1912).

to dark grey or pale greenish, but occasional reddish grey beds are found. They have a dense texture or may resemble in appearance a medium-textured sandstone, and are firm, compact rocks, which occur in heavy, massive beds, so that the stratification is in many cases distinguishable only from a distance. Associated with the arkoses are tuffs which so resemble them that it is generally difficult to tell them apart.

The lower 1,000 feet of the lower beds of the Laberge series consist chiefly of these arkoses and tuffs, but the upper 800 feet contain a considerable development of conglomerate and shale. The conglomerate occurs in thick, massive beds and consists of material varying widely in size. The pebbles and boulders range in size from that of sand grains to larger than a man's head and are mainly either andesitic fragments derived from the Perkins volcanics or pebbles identical in composition with the Coast Range granodiorites. The shales range from light grey to almost black, and usually form successive zones 20 or 30 feet thick and each of a uniform colour.

The 1,700 feet of middle beds consist chiefly of shales like those described above, but characteristically iron-stained and generally presenting a red appearance. When broken, however, they are seen to be grey to black, hard, dense rocks. They occur prevailingly in layers $\frac{1}{4}$ to 1 inch thick, with associated arkoses and sandstones, but the shales predominate.

The upper beds consist almost entirely of medium-textured, somewhat friable sandstones prevailingly greyish, yellowish, or light brown, and occur in heavy, massive beds. These differ greatly from the hard, dense, compact rocks noted in the middle beds.

These rocks occur in Wheaton district in two, parallel, northerly-trending belts, occurring on opposite sides of Corwin valley. They continue north to Granger mountain where coal seams occur. From Granger mountain northwest the middle beds are extensively developed along Ibex river and in the vicinity of Fish lake; to the north towards lake Laberge the tufaceous members of the series become more prominent. The more truly clastic members of the group, therefore, occur in a belt following the margin of the Coast range, and the members composed largely of volcanic material apparently increase in importance to the north and east.

The junior author has made an extended study of the beds occurring to the east and the following descriptions are the results of this study.

The tuffs of the Laberge series in the eastern part of Whitehorse district are of two main types: (1) fine-grained, bedded, and (2) medium-grained, massive. These two varieties occur interbedded, but in places there is a thickness of several hundred feet of one variety without any admixture of the other. The bedded tuff occurs in somewhat greater abundance than the non-bedded.

Typical bedded tuff occurs on the summit of mount Lorne. It is a medium-grey, dense rock with conchoidal fracture. Distinct bedding planes are spaced from 1 to 2 inches apart. Parallel to, and between, these are indistinct narrow bands of a colour slightly darker than the rest of the rock. Roughly parallel joints occur in two planes at right angles to the direction of bedding. A reddish brown, oxidized coating follows the bedding and joint-planes.

The microscope shows the rock to be a clastic, made up of small, angular fragments of feldspar and quartz. The long dimension of a large fragment is 0·1 mm.; there are many around 0·03 and 0·04 mm. in diameter, and many smaller. The feldspar is mostly plagioclase, but some of it has an index of refraction less than Canada balsam and is probably orthoclase. Quartz is present in small quantity. Biotite occurs in the interspaces and appears to be an alteration product. Magnetite is accessory. A few curving bands are richer in biotite and magnetite than the rest of the rock.

In the vicinity of mount Lorne the bedded tuff is interbedded with the coarser, massive variety and intruded by porphyritic dykes.

Mount Michie, a conspicuous, isolated peak east of lake Marsh, is largely made up of Laberge rocks, principally bedded tuff. Its typical colour is dark grey, and in most cases there is an alternation of darker and lighter material in parallel bands of varying thickness, usually from $\frac{1}{8}$ inch to 1 inch. Some layers exhibit a shaly parting parallel to the bedding. Thicknesses of several tens of feet were noted of greenish grey, medium-grained, non-bedded tuff. Certain zones, at most only 2 or 3 feet thick, of the fine-grained, bedded tuff contain elongated, angular rock fragments, oriented parallel to the banding. Considerable variation was noted in the strike and dip, but on the upper slope where the beds are best exposed there seems to be a general dip to the south, at an angle of about 30 degrees. A few dykes of small dimensions cut the bedded tuffs.

A hand specimen from the summit of mount Michie is a medium grey, fine-grained, dense rock (with an indistinct band of darker material), exhibiting conchoidal fracture. The microscope shows that the rock has well-defined clastic texture, and consists of about 75 per cent angular fragments of feldspar, chiefly plagioclase. The diameter of a large fragment is 0·2 mm., the average diameter is about 0·05 mm. A considerable proportion of the grains are elongated and there is a suggestion of roughly parallel orientation. Pyrrhotite, magnetite, and titanite are accessory. The interstitial material consists largely of altered products, kaolin, calcite, abundant chloritic material, iron oxide, and leucoxene. This was originally the finest grained material and would naturally be affected most by metamorphic processes.

A section of somewhat coarser tuff contains fragments up to 0·4 mm. in diameter, with the majority between 0·1 and 0·2 mm. in diameter. Some of the plagioclase is albite. A few fragments of green hornblende are present. In addition there are also fragments of extrusive rocks showing microlitic texture.

The non-bedded tuff is not easily distinguished from an igneous rock such as diabase or basalt. It is an important member of the Laberge series. This rock has been described as a sandstone and has some of the characteristics of an impure sandstone, arkose, or greywacke. It is fine to medium-grained and varies in colour from light to dark grey and from grey to green. In some cases it contains mica, and to the unaided eye appears to have the composition of a granite or diorite. It is interbedded with fossil-bearing shales or argillites and with more or less finely laminated tuffs, in layers from several tens to several hundreds of feet thick. Where exposed the contact with the bedded tuff was seen to be sharp. On the fresh surface the rock is dense, compact, and massive, as if of igneous origin, but in many cases the weathered surface reveals its clastic nature, and, in some cases, bedding planes. Where these were visible their direction was found to be parallel to that of the interbedded, laminated tuffs or shales.

The following description of the microscopic characters of the massive tuff is based on the study of sixteen thin sections, from various points distributed over the eastern half of Whitehorse district. The texture in all cases is clearly fragmental, the great bulk of the fragments being more or less broken crystals of individual minerals with a few of volcanic rocks. This places the rock in the class of the crystal tuffs. In only one case is the proportion of rock fragments large enough to approach that of a lithic tuff. Plagioclase of various compositions is by far the most abundant constituent (that is, among the fragments large enough to be microscopically determinable), and in general makes up from 60 to 70 per cent of the rock. The plagioclase varies from albite ($Ab_{95}$ $An_5$) to andesine ($Ab_{63}$ $An_{37}$) and different plagioclases occur in the same section. Quartz is present as a rule, making up about 15 per cent of the rock (in one case as high as 40 per cent), but in the smaller fragments it is difficult to distinguish from feldspar, making accurate determination of its percentage impossible. Some of the larger quartz grains are rounded and embayed. Green hornblende, somewhat altered to chlorite, is commonly present and in some cases makes up 10 per cent of the rock. Orthoclase is probably present in two of the sections examined, and microcline in one. Potash feldspar may be present in all of them to a very minor degree.

The following accessory minerals were observed: titanite, apatite, biotite, augite, pyrite, and probably pyrrhotite. The feldspar showed varying degrees of alteration to white mica and kaolin. The interstitial material is highly altered, and is to be expected since it consisted originally of the finest volcanic ash. It is typically a dark brownish, cloudy aggregate of various secondary minerals, of which the individual grains are of submicroscopic dimensions. Chloritic material is as a rule prominent and calcite is in some cases present in important amount. Other secondary minerals of less common occurrence are: epidote, zoisite, and leucoxene. In some cases secondary biotite is abundant in the interstitial material and is considered to be the result of igneous metamorphism.

Fragments of rocks were recognized in seven out of the sixteen sections examined. Almost all are extrusives showing microlitic textures. Fragments of shale or of slaty rocks are rare. In the section of a specimen collected about 2 miles south of McClintock peak, fragments of a deep-seated granular rock are prominent, apparently of granitic composition and consisting chiefly of quartz and orthoclase. These fragments, in addition to others of extrusive origin, make up a considerable proportion of the whole. The rock, therefore, approaches the composition of a lithic tuff and is the only one of those examined which could not be definitely classified as a crystal tuff.

The tuffs show more variation in size of grain than they do in the proportions of their constituents. As a rule there is considerable range in the size of the grains in the individual specimen. The larger grains have an average diameter of 0·8 mm. and the average diameter of the majority of the fragments is 0·15 to 0·20 mm.

Apparently all gradations occur between the fine and coarse-grained tuffs and between the non-bedded and finely laminated varieties. They grade on the one hand into shales and on the other into breccias and conglomerates. Where there are only occasional large fragments and the great bulk of the rock is fine-grained, the name tuff seems more appropriate. Rock of this description was noted in a number of localities: on the south slope of mount Lansdowne, 6½ miles east of mount Lorne, 5 miles south and 1 mile east of mount Lansdowne. It is in some places associated with typical volcanic breccia or conglomerate.

Conglomerates, although subordinate in amount to the finer-grained clastics, form a conspicuous and important member of the Laberge series. They are of wide distribution and are somewhat more abundant near the border of the Coast range, becoming progressively less so farther east.

Beside a small lake, 6½ miles east of mount Lorne, is an occurrence of conglomerate apparently surrounded by massive tuff. It consists of a few angular fragments of thin-bedded black shale or argillite and many rounded pebbles of aphanitic igneous rocks, up to 3 inches in greatest dimension, but averaging smaller. A few fossils, chiefly pelecypod shells, are present. Many of the pebbles exhibit shearing effects in the form of series of parallel fracture-planes spaced about ⅛ inch apart and in a direction about 45 degrees to the long axis of the pebble. More or less displacement has taken place along these planes, so that they are really minute faults. Open spaces exist next to some of the pebbles, giving the interstitial material the appearance of having been a pasty lava. The microscope shows, however, that in reality this material is tufaceous and consists of finer fragments of rocks and minerals.

At a point 1½ miles south and ½ mile east of mount Lansdowne there is a thickness of at least 25 feet of conglomerate at the base of an apparently conformable series of about 3,000 feet thickness, consisting chiefly of well-bedded tuff with some intercalated bands of the massive variety. The pebbles in the conglomerate vary greatly in size, shape, and constitution. Tuffs, quartzites, granites, and various rocks of porphyritic texture were among the materials noted. The rounded shape predominates and the larger pebbles, which are as much as 1 foot in diameter, are always well rounded, the smaller being more angular. The matrix is a fine to medium-grained tuff. The conglomerate is underlain by dark grey to black, well-bedded argillite. Fragments of a fossil shell with surface markings resembling those of *Pecten* were found in the talus.

At a point 5 miles south and 2 miles west of mount Lansdowne is an outcrop of conglomerate of which 60 or 70 per cent consists of rounded pebbles of all sizes up to 2 feet in diameter. Limestone is important among the various rocks represented. This is true, also, farther west where conglomerates occur in a belt along the ridge of which mount Caribou forms the highest part. Banded tuffs, fine-grained extrusive rocks, some probably quartz porphyrites and rhyolites, also occur as pebbles in the conglomerate. In one occurrence 2·4 miles northeast of mount Caribou, there are irregular masses of limestone up to 3 feet in diameter.

Conglomerate was encountered in several places in the general vicinity of mount Michie. Here the pebbles are smaller than in the region around mount Caribou. Many of the smaller ones are notably angular and in places give the rock the character of a breccia. They appear to be igneous rocks and quartzites. The field appearance of these conglomerates gives the impression that they occur as somewhat irregular lenses rather than as definite beds in a conformable series. Lack of bedding is a conspicuous feature of the conglomerates, not only in this particular region but elsewhere in Whitehorse district. The lack of assortment as to size and material is almost as complete as in typical glacial till.

West of mount Michie 2·4 miles, and north 4 miles, an exposure of conglomerate of unknown width was traversed for upwards of 2,000 feet. Two varieties were noted, a finer and a coarser, the latter of greater extent. The finer conglomerate contains somewhat angular pebbles, in diameter up to ½ inch, but mostly much smaller, embedded in a dark, fine-grained matrix. The coarser variety contains rounded to subangular, oval, elliptical, and biscuit-shaped pebbles, from 3 inches to 1 foot in diameter. The matrix contains smaller pebbles and is probably of a tufaceous nature. Porphyritic rocks, andesite, limestone, and sandstone, are among the various materials of which the pebbles consist.

Conglomerates associated with bedded tuffs occur at a number of localities in the northeast part of Whitehorse district, in those areas indicated on the map as Laberge series. One mile south and 0·7 mile east of McClintock peak large talus blocks of conglomerate were noted that resemble strongly the conglomerates of Mount Caribou region, but are not so coarse, the maximum diameter of the pebbles being only 6 to 8 inches. Limestone is the material of some of the pebbles.

#### RELATION OF THE LABERGE SERIES ROCKS WITH OTHER FORMATIONS

Only very rarely is there an exposure of the contact between the Laberge tuffs and the Palæozoic limestone. Near the northeast corner of Whitehorse such a contact was seen. Here the bedding of the tuff is parallel to the contact and the tuff appears to overlie the limestone with angular unconformity. The bedding of the limestone, however, is very indistinct, as is usually the case. Nor is the contact of the Laberge series tuffs with the Coast Range intrusive rocks exposed with any greater frequency. Its approximate location can in many cases be inferred by the appearance of the talus on steep hill-sides. On the north side of the Lorne-Wounded Bull massif a very good idea of the character of this contact can be obtained. Its extremely undulating nature and the fact that large apophyses are connected with the main body of the intrusive prove beyond doubt that the tuff is intruded by the granodiorite. Dykes of granitic rocks, probably connected with the larger intrusive bodies, cut the bedded tuffs and the greenstones with which the latter are associated.

## AGE OF THE LABERGE SERIES

Fossils occur in some of the shale beds of the Laberge series in Whitehorse district. Numerous specimens of small ammonoids and pelecypods were collected in two localities, one 2½ miles east-southeast of mount Lorne and the other on the west slope of mount Lansdowne. Other similar occurrences of shale were searched unsuccessfully for fossils, and it may be said that on the whole fossils are of somewhat rare occurrence. The ammonoids collected were submitted to S. S. Buckman, whose report follows:

"The examples submitted reveal the presence in Yukon territory of strata of the Lower Inferior Oolite down to Middle Lias, with some gaps. The accompanying table gives the results. The evidence is in some cases very good; in others doubtful.

*Laberge Series, Southern Yukon*

| English stratigraphic term | English age term | English hemera | Genus | Nature of evidence |
|---|---|---|---|---|
| Lower Inferior Oolite | Ludwigian Canavarinan | aalensis | Pleydellia | Absent (?) Fair |
| | Dumortierian | Dumortieria or moorei | Dumortieria | Fair |
| | | dispansum | Phlyseogrammoceras | Fair |
| | Grammoceratan | (struckmanni pedicum) | Pseudogrammoceras | Good |
| Upper Lias | ................ | striatulum | Grammoceras | Good |
| | Haugian | variabilis | Haugia? | Poor |
| | Harpoceratan | faleiferum | Harpoceras | Poor |
| | | garatum | Elegantuliaras | Poor |
| Milddle Lias | Amaltheian | algorianum | Amaltheus sequenziceras | Good |
| | Liparoceratan | davoei | Prodactylioceras | Fair " |

The fossils indicate the presence of strata ranging in age from Middle Lias to Inferior Oolite, that is of strata of various stages, exclusive of the oldest, of the Lower Jurassic and earliest Middle Jurassic.

Fossils have been collected from the Laberge beds in Wheaton, Atlin, Whitehorse, and Tantalus areas. In the collections from Tantalus area, three forms were specifically identified, viz., *Trigonia dawsoni*, *Nerinea maudensis*, and *Rhynchonella orthidioides*. The specimens were regarded by Whiteaves as Jurassic or Cretaceous,[1] but two if not all three of these species are now regarded as Jurassic forms. Fossils collected by Gwillim in Atlin district were reported on by Stanton as follows: "These may possibly be Triassic, but I think it more probable that they are early Jurassic. They are certainly not as late as the Cretaceous."[2] In Wheaton

[1] Cairnes, D. D.: "Lewes and Nordenskiöld Rivers Coal District"; Geol. Surv., Canada, Mem. 5 pp 34-35 (1910).

[2] Gwillim, J. C.: Geol. Surv., Canada, Ann. Rept., vol. XII, pt. 3, pp. 23-27 (1899).

and Whitehorse districts Cairnes reports numerous specimens of *Prioncyclus woolgari*, of which Whiteaves said "*Prioncyclus woolgari* Mantell, several crushed specimens of an ammonite that are possibly very young individuals of this species." In view of the more positive evidence afforded by other collections of fossils, it seems highly probable that the tentative identification of *P. woolgari* by Whiteaves should be disregarded. Thus it appears to be very well established that the Laberge beds range in age from middle Lower Jurassic to lower Middle Jurassic.

In reviewing the evidence as to the age of this series, it should be stated that, owing to the thickness of the Laberge beds and to the fact that the fossils forming the basis of the latest determination were collected from two localities only, some doubt exists as to whether the whole range of the Laberge series is represented by the horizons determined by these faunules. The eastern section, from which these fossils were obtained, probably does not reach the top of the series, as the overlying Tantalus conglomerate was not recognized in the section. For the present, therefore, the Laberge series may be referred to the Jurassic with the knowledge that the range from the middle part of Lower Jurassic to the lower part of Middle Jurassic has been recognized, and with the possibility that these limits may be further extended when more detailed stratigraphic study be undertaken.

## Tantalus Conglomerate

The Tantalus conglomerates are of only very limited areal extent in this district, and for the purposes of mapping it was found necessary to include them in the Laberge series. The chief exposures occur in Wheaton district on Bush and Follé mountains, and also on the summit of mount Bell. To the north they are developed in the vicinity of Granger mountain.

### LITHOLOGICAL CHARACTERS

The Tantalus conglomerates consist chiefly of massive beds of conglomerate, but contain also sandstones, shales, and coal seams. The thickness as measured by Cairnes in Wheaton district is 1,700 to 1,800 feet. These conglomerates differ from all others of Yukon in that they are composed almost entirely of pebbles of quartz, chert, and slate, the pebbles being generally cemented by a siliceous matrix. The component pebbles are remarkably uniform in size, rarely exceeding 3 inches in diameter and for the most part being between 1 and 2 inches in diameter. The associated sandstone consists of the same materials as the conglomerates, but in a finer state of division. The shales occur chiefly in the vicinity of the coal seams and are generally finely textured rocks with a slaty cleavage.

### AGE

The Tantalus conglomerate overlies, to all appearance, conformably, the Laberge series. So far as is known the Tantalus conglomerates in Whitehorse district are the same as those described from the type area, namely Tantalus coal mine on Yukon river. In both localities the lithological similarity is striking and the contained fossils belong to the same horizon. Fossil plants from the coal seams were examined by Dr. Penhallow, who says: "All the material appears to be the same as the specimen of *Thyrsopteres elliptica* Fontaine, as figured by Ward in the 'Status of the Mesozoic Floras of the United States,' vol. XLVIII, Pl. LXXI, figs. 12 and 13; and to this the present specimens are provisionally referred. It is to be observed, however, that there seems to be some question as to the correctness of Ward's reference, since the specimen cited is quite distinct from the original type of *Thyrsopteres elliptica* as described by Fontaine (in 'Potomac Flora,' vol. XV, Pl. XXIV, figs. 3, 3a, p. 133) and it is quite possible that further and more complete specimens may show this to be an entirely new species. A somewhat related flora was described by me in 1898 as obtained by Mr. J. B. Tyrrell from the Nordenskiöld river. All the specimens shown, however, were specimens of *Cladophlebis* and they indicated Cretaceous age."

"The specimens from the Tantalus mine present a flora with the same facies as those from the Nordenskiöld river, and the whole conforms to the flora of Kootanie age."[1]

More recent work in 1915 on the Tantalus conglomerate in Wheaton area, a part of Whitehorse district, resulted in further specimens being collected, of which Cairnes[2] wrote, "fossil plants from these beds, collected during the past summer, which have been determined by Dr. F. H. Knowlton, of the United States Geological Survey, to be of Jurassic age. Dr. Knowlton also states that some of the species have been found in the Kootenay or at least have been reported from that formation." In view of the latter statement and the fact that the beds contained coal seams and were lithologically very similar to the Kootenay, Cairnes classed them as probably belonging to that formation.

The plant evidence given above, however, seems to corroborate the animal evidence obtained from the Laberge beds, and there can be little doubt that the Laberge beds and Tantalus conglomerate are both of Jurassic age, and it would appear that the earlier determinations of fossils are to be regarded as extremely doubtful in the light of the more exact evidence now presented.

## Older Volcanics

The rocks of the Older Volcanics group are chiefly andesites, diabases, and basalts. Smaller quantities of deep-seated, basic rocks such as diorite, gabbro, and amphibolite have been included. Areas of the Older Volcanics are fairly abundant in the central part of Whitehorse district along the margin of the Coast Range intrusives. In the eastern part of the area the major occurrences extend along a line from Tagish lake towards lake Laberge, to a portion of which Dawson gave the name Diabase range.

### LITHOLOGICAL CHARACTERS

These rocks are typically compact, finely textured, and dark green, but red, brown, and blue types also occur. They are prevailingly porphyritic, with feldspar crystals $\frac{1}{8}$-inch or more in length, in an aphanitic ground-

[1] Cairnes, D. D.: "Lewes and Nordenskiöld Rivers Coal District"; Geol. Surv., Canada, Mem. 5, p. 38 (1910).
[2] Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1915, p. 41.

mass. In some cases phenocrysts of hornblende and biotite may be discerned with the naked eye. Iron in the form of magnetite or pyrite is commonly present, and in many cases has oxidized, giving a distinct reddish or brownish colour to the rocks. Tuffs and breccias occur in many places.

Under the microscope the rocks are seen to possess a variety of compositions and of structures. Plagioclase is always present and generally occurs in two generations. It ranges from oligoclase to bytownite in composition, but by far the more common plagioclases are andesine or labradorite. The acid plagioclase is present chiefly in the groundmass of the rocks. Orthoclase occurs in a few cases as phenocrysts, and also in the groundmass. The ferromagnesian minerals include hornblende biotite, pyroxene, and olivine. Both the common green hornblende and brown basaltic hornblende occur, but the former is by far the more common. Biotite is also common and is in some cases the only ferromagnesian mineral present. Biotite and hornblende occur together, and exist in both generations. Pyroxene, usually diopside, is present, but seldom in phenocrysts of sufficient size to be detected with the naked eye. Olivine has been noted in some of the augite andesites. Pyrite and magnetite are abundant, in many cases in specks large enough to be detected with the naked eye.

The alteration of these rocks in some cases is well advanced, and in many instances masks the original character. Calcite, chlorite, epidote, and zoisite are abundant as secondary constituents.

The structure of the rocks is usually porphyritic, and the phenocrysts, as described above, consist of plagioclase and the ferromagnesian minerals. Phenocrysts are as a rule fairly abundant. The groundmass is either holocrystalline or partly glassy; in the former case the structure is in most cases pilotaxitic, and in the latter hyalopilitic.

The rocks range from andesites to basalts. In the former class hornblende andesites, mica andesites, and augite andesites are present. The tuffs and breccias mentioned above are largely andesitic in character.

Some rocks of deep-seated character have been included, particularly in the eastern part of the district. These will be noted in the more detailed petrographic descriptions, by the junior author, which follow.

### *Mount Nares Area*

Here the rocks are characteristically of a greenish colour, massive, and from fine to medium-grained. A local development of schistosity is to be seen on the south side of the valley of Crag lake where the greenstone is cut by numerous, light grey to cream-coloured dykes that vary in width from a few inches to 10 feet or more.

A thin section of country rock from about 2¾ miles northeast of mount Nares was seen under the microscope to contain about 80 per cent green hornblende, probably uralite, ranging in habit from fairly large crystals to fine shreds. The remainder of the section consists chiefly of a mineral of low birefringence which may be quartz or plagioclase or both. The rock formerly may have had an ophitic texture and probably is an altered basic volcanic such as diabase or basalt.

One mile east of Nares station the country rock is fine-grained, dense, and greenish grey in colour. It is traversed by many, small, straight veins of zoisite with some quartz. Under the microscope the chief constituent is seen to be finely divided green hornblende, with a small amount of feldspar and quartz. There is a certain amount of parallel orientation of the particles, although no schistose structure appears in the hand specimen. The whole area of the section except the veins is dirty and opaque in appearance, due to the presence of alteration products: chloritic material, yellow iron oxide, and zoisite. Magnetite is accessory. There is nothing in the microscopic character of the rock to show that it is not a metamorphosed sediment, but its field relations suggest that it is of igneous origin.

A specimen from the hill 2·5 miles east of mount Nares is a dense, dark grey, fine-grained, heavy rock, high in dark mineral. Under the microscope this rock is seen to have a sub-ophitic texture. It contains about 57 per cent labradorite ($Ab_{37}$ $An_{63}$), 40 per cent brownish hornblende, possibly derived from augite, and 3 per cent magnetite. All these minerals are automorphic, but the laths of labradorite penetrate the hornblende. Calcite and chlorite are abundant secondary minerals.

Thin sections of dyke rocks from these three localities show great diversity in composition. One is a porphyrite, another a porphyry with some development of spherulites, and the third is a rock of unusual composition, consisting of approximately 40 per cent actinolite (or green hornblende) and 60 per cent zoisite.

### *Area Northeast of Tagish*

Ten miles east-northeast of Tagish is an area of several square miles of "Older Volcanics." The country rock in most of this area appears to be greenstones like those of the Mount Nares region.

### *Diabase Range Area*

An important area of the greenstones occupies the southern part of the ridge which runs northwest from the northern end of lake Marsh and separates the valley of Lewes river from that of the McClintock. Dawson called this the "Diabase range." Similar greenstones occur on the east side of McClintock valley near lake Marsh, but these are not shown on the map because of their intimate association with bedded tuffs of the Laberge series.

Rock is well exposed on the steep side of the "Diabase range" facing McClintock river. The rock may be seen from base to summit, which here differ in elevation by nearly 3,000 feet. It is everywhere massive. Small dykes of porphyritic greenstones were noted at various points and also small veins of epidote. Near the base of the slope the rock is greenish grey, medium-grained, and granular. It consists of about 45 per cent dark mineral and 55 per cent light. In places a porphyritic texture is visible on weathered surfaces. There is considerable variation both in texture and composition. As seen under the microscope certain patches are comparatively clear and here laths of plagioclase with slightly rounded corners lie in a background of untwinned orthoclase. The plagioclase is andesine ($Ab_{56}$ $An_{44}$), but is very much altered to shredded white mica. The chief ferromagnesian constituents are green hornblende (uralite) and biotite, both partly chloritized. A little augite is present. Magnetite is present in rather large, irregular grains to the amount of approximately 2 per cent. Apatite is a very abundant accessory and zircon is present.

Higher up the ridge the rock is finer, mostly aphanitic, and much of it holds small phenocrysts of dark mineral with occasional feldspar phenocrysts. The rock appears to be very rich in dark mineral and quite uniform in texture and composition over a considerable area. In colour it varies from dark greenish to purplish. Although the appearance of the hand specimen gives no indication of clastic texture, the microscope shows that the rock is distinctly fragmental, consisting of about 75 per cent angular fragments of augite andesite and basalt of various textures. The smaller pieces have an average diameter of about 0·4 mm. There is a small quantity of fine-grained, opaque, interstitial material which is greenish by reflected light.

The summit and western slope of the "Diabase range" consist of greenstone for a distance of nearly 12 miles northwest of the lower end of lake Marsh. For 5 or 6 miles the eastern slope consists chiefly of coarse and fine-grained, bedded tuffs with a fairly constant strike parallel to the trend of the range, and a dip to the southwest of 33 to 40 degrees. This makes it apparent that the tuff underlies the greenstone. From a point on the summit of the ridge 7 miles northeast of the mouth of McClintock river a good view was obtained of the bedded tuff dipping beneath the greenstone in a hill $1\frac{1}{2}$ miles southeast of the point of observation. At this distance the contact appeared fairly sharp.

A specimen collected from a point near the north end of the "Diabase range" area is a dark green, fine-grained rock with a few phenocrysts of a dark green mineral. Under the microscope the phenocrysts are seen to be chiefly augite and plagioclase, the former predominating. There are also some phenocrysts entirely altered to calcite and serpentine, which may have been derived from olivine. The groundmass consists of large, plagioclase microlites arranged in flow lines around the phenocrysts and embedded in a partly devitrified glass. The plagioclase is labradorite ($Ab_{47}An_{53}$). Magnetite, occurring in scattered grains, is an abundant accessory. There is a considerable amount of secondary calcite, chlorite, and serpentine. About 1,500 feet west of where the last-described specimen was collected the greenstone is porphyritic and this phase seems to grade into the fine-grained rock. Large prisms of dark green hornblende are conspicuous in the hand specimen. Under the microscope the rock is seen to be so much altered that determination of its original nature is difficult. The phenocrysts are brown hornblende and feldspar.

A specimen from a point on top of the ridge, 7 miles northwest of the mouth of McClintock river, is dark purple with greenish mottling. It is fine-grained, and there are a few cleavage faces of small phenocrysts. Microscopically examined it is apparent that about 60 per cent of the phenocrysts are labradorite, varying in length from about 2 mm. to small microliths. The remaining 40 per cent of the phenocrysts consist of an altered ferromagnesian mineral, probably pyroxene. Some chlorite areas appear to be fillings of vesicles. In some cases what appear to be vesicles are filled mainly with quartz having a border of chlorite. Titanite and leucoxene are present.

*Michie Creek Area*

A smaller area of greenstone occupies the region between McClintock river and Byng creek. It is bounded on the south by the valley of Michie creek. In the greenstone of this area no bedding or other indication of sedimentary origin was seen, neither was there any appearance of pillow structure, scoriaceous texture, columnar jointing, or other indication of surface lava flows. The massive structure suggests that the rock is either intrusive or the more deeply seated parts of thick flows. It is fine-grained and dark green, grading here and there into a lighter-coloured variety. The weathered surface is dark reddish brown. In places there is a considerable amount of serpentine which is most evident on slickensided surfaces in cleavage cracks. Two thin sections of typical rock from this area show that it is composed mainly of altered products. In one of them there are some small remnants of olivine; magnetite occurs in small, scattered grains and also as fine dust arranged in curving lines. The rock was probably a peridotite. The other rock is quite different, although megascopically it appears similar. Certain areas consist of unoriented needles of pale green actinolite in a background of feldspar. These areas alternate with irregular, lens-shaped areas of massive, pale green hornblende, partly chloritized, and which feathers out at the edges into actinolite needles. Magnetite in scattered grains is an abundant accessory. The rock might be termed an actinolite schist, although schistose texture is not well developed.

*Mount Byng Area*

The greenstones composing mount Byng include, in addition to the more usual fine-grained varieties, some fairly coarse, granular rocks rich in hornblende. Conglomerates and bedded tuffs occur on the south flank of the mountain. The uppermost part of the mountain is a fairly sharp ridge extending north and south for about half a mile. The rock is entirely greenstone except for a few dykes. Specimens collected at the south shoulder and at the highest point are both dark greenish grey and medium-grained. The thin section of one of these specimens consists of 40 per cent labradorite ($Ab_{46}An_{54}$) and 60 per cent green, faintly pleochroic hornblende. Needles of actinolite are abundant near the edges of the hornblende and occur to some extent scattered through the feldspar areas. The feldspar is fresh and unaltered. The rock has the composition of hornblende gabbro. In the case of the second specimen the rock consists of about 50 per cent green hornblende, 48 per cent andesine ($Ab_{52}An_{48}$), and 2 per cent magnetite. The feldspar occurs in laths in a background of hornblende. The rock has the appearance of a typical diabase, the hornblende having probably been derived from augite.

*Cap Creek-Mount Juno Area*

A continuous belt of greenstones, nearly 18 miles in length, makes the ridge which borders on the east the valley of Cap creek and culminates toward the north in mount Juno. Perhaps the belt continues beneath the drift of McClintock valley and joins the greenstone area of Michie Creek district. North of this McClintock valley appears to be underlain by granodiorite, which borders and intrudes the greenstone belt on the east. The contact between greenstone and granodiorite follows a very irregular course, as is well illustrated in the area 4 miles northeast of the junction of Cap creek and McClintock river, where the greenstone and the intrusives occur in alternating areas. Dykes of light-coloured porphyries are fairly numerous in the greenstones. They probably are connected with the main intrusive body of granodiorite. The principal rock which flanks the greenstone belt on the west seems to be Laberge bedded tuff. An area of the tuff occurs east of Cap creek and 4 miles northeast of mount Cap; the strata strike in the direction of the ridge and dip steeply to the west. As in other parts of the area, the greenstone and the tuff seem to grade into one another; this was noted by Gwillim at Cameron mountain in Atlin area.[1]

The thin section of one specimen of greenstone, at a point 1·5 miles west of the junction of Cap creek and McClintock river, under the microscope is seen to be so altered that the original texture is obscured. It was probably granular, holocrystalline, and possibly somewhat porphyritic. About 60 per cent of the rock consists of large, irregular laths of oligoclase. Micropegmatite occurs in the spaces between the plagioclase laths, and quartz in irregular grains is fairly abundant. Secondary minerals are prominent. The rock is possibly a diorite or a diorite porphyry. A specimen collected 3·5 miles south of Mount Juno station, as seen under the microscope, is also greatly altered. Titaniferous augite, partly uralitized, is an abundant constituent. Quartz is present in the form of large, much corroded grains. The groundmass consists of finely divided alteration products. The rock may have been a diabase or a diorite. The thin section of a specimen collected 1·3 miles east of mount Juno, seen under the microscope, consists of about 25 per cent acid plagioclase microlites, 5 per cent magnetite, and 70 per cent green hornblende in the form of small, irregular laths. White veinlets are conspicuous in the hand specimen, and these under the microscope are seen to be filled chiefly with quartz and epidote. The rock is possibly an andesite or a fine-grained phase of the diorite family. A specimen collected 2¾ miles westward of Mount Juno station has a microlitic texture, but is not so fine-grained as the one last described. The small plagioclase laths make up about 30 per cent of the rock and appear to be andesine. The interstitial material is cryptocrystalline and consists in part of material with a greenish to brownish pleochroism, and in part of a greyish alteration product stained by chlorite and probably derived from interstitial feldspar. The rock is probably an andesite.

### AGE OF THE OLDER VOLCANICS

In his earlier work Cairnes[2] separated the "Older volcanics" into two groups, the Perkins group and the Chieftain Hill volcanics. This subdivision was subsequently abandoned and[3] both were included in one group

[1]Geol. Surv., Canada, Ann. Rept., vol. XII, pt. B, p. 28.
[2] Cairnes, D. D.: "Wheaton District"; Geol. Surv., Canada, pp. 46-51, 59-64 (1912).
[3] Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1915, p. 42.

and correlated with the Older Volcanics of White River district.[1] Portions of the Older Volcanics are definitely intrusive into the Laberge beds, and may, therefore, be considered younger. The similarity between the tuffs of the Laberge beds and those of the Older Volcanics has been pointed out by Cairnes, who believed that the period of vulcanism represented by the Older Volcanics was in some measure contemporaneous with the deposition of the Laberge beds. Gwillim[2], referring to the Older Volcanics, says: "This group appears to be closely connected with the origin of the sandstones, of which they may be the non-fragmental representatives" and further, "the change from the tufaceous fragmental rocks of this mountain (Cameron mountain), to the porphyrites and andesites is gradual and indefinite." In fact the difficulty in the field of distinguishing between these rocks necessitated a certain amount of generalization in their mapping. The rule followed was to represent as Laberge all areas of rock dominantly clastic, even though there was little or no bedding, and to show as Older Volcanics those areas where flows predominated.

The Older Volcanics are, probably, all older than the granitic intrusives. Although some of the flows are more recent than the beds of the Laberge series with which they come in contact, the writer is of the opinion that they are to a large extent contemporaneous with the Laberge beds, and are probably of Lower and Middle Jurassic age; and that the tuffs, which are so plentiful in the Laberge series, are to be attributed to the same period of vulcanism.

## Coast Range Intrusives

The eastern boundary of the Coast Range batholith, so far as Whitehorse district is concerned, is nowhere well defined. Inclusions of older rocks and covers of later rocks render it uncertain whether particular bodies of granite belong to the main mass or to outlying bodies. The character of this eastern boundary of the batholith is perhaps best shown by the Wheaton River map,[3] where detailed mapping on a scale of one mile to the inch was undertaken. However, if a line be drawn from lake Bennett northwestward across Wheaton river to Ibex river, it will be found that west of this line granitic rocks predominate, and east of this line they are subordinate.

### LITHOLOGICAL CHARACTERS

The rocks grouped under the head of Coast Range intrusives present many different types. They are generally grey in colour, and fresh and unaltered in appearance. In some cases, however, pink feldspar is present in sufficient quantity to give a pinkish cast to the rocks, but on the whole this is exceptional. In texture they have the appearance of medium to coarse-grained granites. Locally, phenocrysts of feldspar, many exceeding 1 to 2 inches in length, are developed, and the rocks may be said to have a porphyritic texture. Quartz, orthoclase, plagioclase, and ferromagnesian minerals, in nearly every case hornblende and biotite, can readily be detected by the unaided eye.

[1] Cairnes, D. D.: "Upper White River District"; Geol. Surv., Canada, Mem. 50, pp. 87-93.
[2] Gwillim, J. C.: "Atlin Mining District"; Geol. Surv., Canada, Ann. Rept., vol. XII, pt. B, p. 28.
[3] Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1915.

When examined under the microscope, the majority of the sections are seen to contain quartz, orthoclase, microcline, plagioclase, hornblende, biotite, and, only in some cases, augite. The amount of quartz varies greatly, but is mostly between 10 and 25 per cent, feldspars from 60 to 75 per cent, and the remainder is hornblende and biotite, or augite. Orthoclase and microcline are as a rule about equal in amount to the plagioclase. Plagioclase is most commonly oligoclase or andesine. The hornblende and augite in many places are intergrown. Biotite is present as a rule.

The typical rock would, therefore, seem to have a composition midway between granite and quartz diorite. To this the name granodiorite has been applied. The term monzonite has been adopted by numerous petrologists for rocks midway between granite and diorite; according to this usage the typical rock of the Coast Range intrusives could be termed quartz monzonite, or, according to the definition of Brögger, adamellite.

With an increase of the orthoclase and decrease of the plagioclase, typical granites have been noted, and the decrease of orthoclase and increase of plagioclase and augite give rise to diorites. The relation of these phases to the more typical rock has not been studied.

No analyses of the granitic rocks of Whitehorse district are available. Cairnes gives an analysis of a typical specimen from Atlin district to the south.[1]

| | Per cent |
|---|---|
| $SiO_2$ | 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 |
| $TiO_2$ | 0·23 |
| $P_2O_5$ | 0·07 |
| $CO_2$ | .... |
| $MnO$ | trace |
| $H_2O$ (at 110° C.) | 0·03 |
| $H_2O$ (above 110° C.) | 1·05 |
| | 100·45 |

"This analysis indicates that this particular specimen might be termed either a calcic granite or a granodiorite, but under the microscope the rock appears to be decidedly a granodiorite."

In the eastern part of the area these intrusives are of rather limited extent, but are exposed on parts of the upland surface in the vicinity of the higher peaks. The following descriptions by the junior author indicate that the types represented in these outlying bodies vary but little from those present to the west and south.

North of mount Lorne and mount Wounded Bull is an area of about 6 square miles in which the typical rock has a medium-grained, granular texture, and a light grey colour. Megascopically the dark mineral appears to make up between 5 and 10 per cent of the rock and to be nearly all biotite. A few miles south is an area of about 18 square miles of pink granite porphyry. This rock seems to be mostly fairly uniform in character, but at lower elevations grades into rock with a more typically granitic

[1] Cairnes, D. D.: "Atlin Mining District"; Geol. Surv., Canada, Mem. 37, p. 58 (1913).

texture. About half the volume of the rock appears to be made up of phenocrysts of light-coloured plagioclase and a few of quartz. The groundmass is granular and consists of pink orthoclase, quartz, and a ferromagnesian mineral. Under the microscope, the approximate mineral composition is seen to be: quartz 20 per cent, orthoclase, microperthite, and oligoclase ($Ab_{94}$ $An_6$) together 73 per cent, and green hornblende 7 per cent. There appears to be slightly more orthoclase than plagioclase. Magnetite, apatite, and titanite occur as accessories. There are some pegmatitic intergrowths of quartz and feldspar. The rock is a coarse adamellite porphyry.

In the saddle east of mount Lansdowne, medium-grained granodiorite grades into a finer-grained border phase. No sharp contact with the bedded tuffs is apparent here. The tuffs are cut by dykes and apophyses from the main intrusive body.

Near mount Caribou the intrusives are partly porphyritic and partly granular. The porphyritic variety is grey. Larger plagioclases and smaller hornblendes form phenocrysts in a fine-grained, grey groundmass. Under the microscope the most abundant constituent of the porphyritic variety is seen to be andesine ($Ab_{56}An_{44}$). Orthoclase is plentiful, but quartz is subordinate. Ferromagnesian minerals are important, the chief variety being diopside largely altered to green hornblende. Accessory minerals present are, biotite, magnetite, and apatite. The rock is an adamellite porphyry (quartz monzonite porphyry). Specimens of the granular variety are coarse grained and consist of about 40 per cent dark mineral and 60 per cent light grey feldspar. Under the microscope the estimated proportions of the primary constituents is as follows: quartz 6 per cent, orthoclase 15 per cent, labradorite ($Ab_{48}An_{52}$) 67 per cent, ferromagnesian minerals 12 per cent. The latter include diopside, partly altered to green hornblende, and biotite. The rock is a quartz gabbro, not far removed from a quartz diorite.

Granular rocks are exposed in the saddle east of a peak 9·5 miles northwest of mount Michie and form the upper part of a ridge northward for about one mile. They are dominantly medium grained, light greyish or buff coloured, and have a low content of dark minerals. Seen under the microscope the average composition of three specimens is: quartz 35 per cent, orthoclase 32 per cent, oligoclase ($Ab_{93}An_7$) 30 per cent, biotite 3 per cent. The average composition is that of a granite, but the ratio of plagioclase to orthoclase varies between that of a granite and a granodiorite. All the rocks fall within the limits of adamellite.

The large area of Coast Range intrusives in the region of upper McClintock valley contains rocks of medium to coarse, granular texture and of varying composition. At a point about 3½ miles northeast of the junction of Cap creek and McClintock river the rock is high in quartz and plagioclase (albite or acid oligoclase), low in orthoclase, and contains considerable biotite, and hornblende. Three specimens collected at various points near the eastern border of this area (in almost a straight line south from mount Byng, along the west bank of Byng creek) show great variation in the amount of dark mineral (chloritized biotite and some green hornblende) present.

On the low ridge east of McClintock river a specimen of typical rock is coarse-grained, granular. It consists of 40 per cent quartz, white to cream-coloured, feldspar (orthoclase 20 per cent, oligoclase 35 per cent), and between 5 and 10 per cent dark material, mostly biotite, but also some prisms of hornblende.

At various places in the eastern half of Whitehorse district large dykes, varying in composition from granitic to dioritic, and in texture from porphyritic holocrystalline to hypidiomorphic-granular, intrude the greenstones and bedded tuffs. These dykes are believed to be connected with larger intrusive bodies. There is a notable absence of pegmatite and other differentiated dyke rocks in the area as a whole, although in places there are small aplitic dykes.

### AGE OF THE COAST RANGE INTRUSIVES

The problem of the age of the Coast Range intrusives in Yukon has occasioned discussion. In writing on Wheaton district Cairnes[1] claimed that the batholith antedated the Mesozoic Laberge beds. This statement, however, was subsequently corrected both in the Atlin report[2] and as a result of later work in Wheaton district[3] when he recognized the fact that the granites cut the uppermost of the Laberge beds and even the Tantalus conglomerates. A prominent feature of the Laberge beds is conglomerates which contain pebbles and boulders of granitic rocks identical in character with the Coast Range intrusives. From this data Cairnes concluded that the Coast Range intrusives, although lithologically very similar, were intruded at different times; that parts of the batholith were intruded and deroofed to supply material for the Laberge beds; and that this period of sedimentation was followed by further intrusion.

Nothing, however, has been put forward to show that these pebbles and boulders were actually derived from the Coast Range batholith, except their lithological similarity to the intrusives now found. For purposes of age determinations, this evidence is largely valueless. Rocks of lower Palæozoic age containing dioritic pebbles have been found on the Alaskan coast.[4] It is, therefore, more reasonable to consider the Coast Range intrusives with respect only to the rocks which they cut. The later determination of the age of the Laberge beds as Lower and early Middle Jurassic limits to some extent the age of the intrusives. They are not earlier than the lower part of the Middle Jurassic. With regard to the upper limit of their possible age the evidence is less certain. It has not been definitely established that the Upper Jurassic is not represented by some part of the Laberge series, and the age of the Tantalus conglomerate remains in doubt. Cairnes was of the opinion that the Tantalus conglomerates are older than the intrusives. The Tantalus, he provisionally assigned to the Kootenay, or at least correlated the Tantalus with other strata in northwestern British Columbia which on the evidence of plant remains had been assigned to the Kootenay, a formation of Lower Cretaceous age. But Knowlton,[5] after examining one collection of fossil

[1] Cairnes, D. D.: "Wheaton District"; Geol. Surv., Canada, Mem. 31, p. 53 (1912).
[2] Cairnes, D. D.: "Atlin Mining District"; Geol. Surv., Canada, Mem. 37, p. 59 (1913).
[3] Geol. Surv., Canada, Sum. Rept. 1915, p. 42.
[4] Buddington, A. F.: Personal communication.
[5] Geol. Surv., Canada, Sum. Rept. 1915, p. 41.

plants from the Tantalus, pronounced them to be Jurassic. No other sedimentary formations in Whitehorse district serve to indicate the upper limit of the age of the intrusives. The batholith may, therefore, be regarded as Upper Jurassic or later.

## Newer Volcanics

An important group of volcanic rocks comprising mainly andesites and basalts occurs in the western part of the district near Skukum mountain (Plate VII). Isolated patches of scoria and basalt occur near Ibex river, and within Whitehorse Copper belt, where Lewes river has cut through them to form Miles canyon (Plate VIII). These various developments and the Carmack basalts of Cairnes[1] are included in the Newer Volcanics.

### LITHOLOGICAL CHARACTERS

The andesites and basalts have a bright, fresh appearance, but on close examination are seen to be deeply weathered, so that it is difficult to secure a fresh hand specimen. Black, and various shreds of green and grey, predominate, but reds, ranging from a dull brick-red or even purple to bright vermilion or even lavender, are by no means rare. Black scoria is abundant, and tuffs which, seen from a distance, are white to light pink, are abundantly developed in the vicinity of Chieftain hill and to the east of Summit creek.

Microscopically, the andesites and basalts are seen to be porphyritic rocks with phenocrysts of plagioclase and augite. The plagioclase feldspars range from oligoclase to bytownite, but are usually andesine, labradorite, or bytownite. Both common green hornblende and basaltic hornblende occur. The pyroxene is mostly diopside or hypersthene and some olivine is present. The chief alteration products are calcite, epidote, and chlorite. The texture is generally pilotaxitic, but where glass is present may be denoted as hyalopilitic.

### AGE

The rocks have been studied in a number of localities in Yukon, and wherever definite determinations could be made they have been assigned to the late Tertiary or early Pleistocene. In Whitehorse district they cut the Older Volcanics and the Coast Range intrusives, and are in turn intersected by the Acid Volcanics. Mendenhall,[2] who studied similar flows in the Copper River regions of Alaska, says "These flows, therefore, instead of preceding the deformation of the early Tertiary plain, are later than the dissection which followed its uplift, and are to be regarded as very recent indeed." In Whitehorse district it is certain that at least some of the flows have been poured out since the valleys were cut approximately to their present depths. This is apparent in the case of Miles canyon where Lewes river has cut through a basalt flow in the valley to a depth of probably less than 100 feet.

[1] Cairnes, D. D.: "Wheaton District"; Geol. Surv., Canada, Mem. 31, pp. 64-65 (1912).
[2] Mendenhall, W. C.: "The Geology of the Central Copper River Region, Alaska"; U.S. Geol. Surv., Prof. Paper No. 41, pp. 54-62 (1905).

## Acid Volcanics

In the eastern half of Whitehorse district the only occurrence of the "Acid Volcanics" is in a zone about 8 miles long and 2 miles wide just east of, and parallel with, the upper part of Byng creek. In the southern part of this zone, 9 miles south and southeast of mount Byng, there is a variety of light-coloured, fine-grained, porphyritic rhyolites. They are massive and the only structural feature noted was widely spaced jointing. The rhyolites are intruded by small, porphyritic dykes. Some of the palest varieties resemble quartzite in the hand specimen. On fresh surfaces these rocks are very light grey, almost white, but vary from this to medium grey with a purplish cast. Scattered, small, brown and black spots of iron oxide occur. These have probably been derived from pyrite which in some cases still retains its border of iron oxide. A specimen representing the dominant rock of the south end of the ridge is light grey and fine grained. It has a flinty appearance and conchoidal fracture. The effect of fine, parallel banding is given by numerous, small lenses of white material. Under the microscope the rock is seen to be porphyritic, with phenocrysts forming from 5 to 8 per cent of the whole. The phenocrysts are 60 to 80 per cent feldspar, chiefly plagioclase, the remaining 40 to 20 per cent is quartz. The quartz individuals are rounded and some are embayed. The plagioclase phenocrysts as a rule have well-defined crystal boundaries, but some have irregular outlines, and in one section a greater abundance of these irregular forms gives the rock somewhat the appearance of a tuff. The groundmass is a holocrystalline, medium to fine-grained aggregate of quartz and feldspar, the latter probably in greater abundance. In places there is an imperfect spherulitic texture. There are more or less distinct flow lines around the phenocrysts. Secondary quartz has been deposited in rather indefinite small stringers. Other secondary minerals present are red and brown iron oxides and chlorite, pyrite, and green hornblende occur as accessories. These rocks have the character of aporhyolites.

Toward the northern end of the zone the rocks are somewhat different in character, but are still dominantly acid volcanics. Tuffs are more prominent, but flows are still important and it is difficult to distinguish the two in the field. The rocks are very massive and have conspicuous vertical jointing. On the side of a valley they stand up in striking fashion as a series of vertical cliffs. No bedding or banding was seen. In colour these rocks vary from light greenish grey to purplish grey, the latter being more characteristic. Small, white fragments or phenocrysts are sparingly scattered through a cryptocrystalline darker groundmass. In places angular fragments of older rocks are scattered, which appear to be inclusions, but the microscope proves the matrix to be tufaceous in character. One such fragment is 4 cm. long, and is a reddish brown, fine-grained, dense rock, possibly a basalt or an altered sediment. There are some rounded fragments of a coarse-grained granodiorite with white feldspars and numerous smaller fragments in the dense matrix. The total of the visible fragments makes up only a small proportion of the whole rock. The microscope shows that although these rocks are apparently a unit in their field relations, since there is a gradation from one type to the other, there are really two distinct types, the one a flow and the other a tuff. In one section the rock consists of many angular and irregular fragments of quartz and feldspar embedded in a glassy groundmass partly devitrified, but not so much so as in the case of the aporhyolites described above which occur farther south. The phenocrysts of plagioclase are of andesine ($Ab_{37}An_{63}$). White mica, chlorite, brown iron oxide, and calcite are present as secondary minerals. The rock may have the composition of a rhyolite, dellenite, or dacite, more likely a dacite. The second type has a distinctly fragmental texture and is made up of angular fragments of variable size. One of these, several millimetres long, is a granite or granodiorite. There are also fragments of extrusive rocks and smaller ones of individual minerals, quartz and feldspar, some of which is much altered to calcite. Other secondary minerals present are chlorite, calcite, and red iron oxide; apatite, zircon, and titanite are accessory.

About 1 mile southwest of the summit of a hill 4 miles southeast of mount Byng, is an outcrop of granite porphyry. It is light pink, fine-grained, and porphyritic; a few cleavage faces of feldspar are visible in the hand specimen. Under the microscope the rock is seen to be a typical granophyre. Plagioclase phenocrysts, an acid oligoclase, and a few of orthoclase make up about 30 per cent of the rock. The groundmass has the general effect of a granular rock, but each grain is made up of a micro-pegmatitic intergrowth of quartz and orthoclase.

Except for the occurrences in Wheaton district described by Cairnes, the only area of these rocks shown on the map in the western half of Whitehorse district is 6 miles east of the southern end of Mud lake.

### AGE AND CORRELATION OF THE ACID VOLCANICS

No new evidence was obtained in the eastern half of Whitehorse district concerning the age of the "Acid Volcanics." In Wheaton district these rocks were considered by Cairnes to be late Tertiary or Pleistocene. He observed volcanic necks, surface flows, and tufaceous accumulations in their characteristic forms and concluded that they were of comparatively late origin. The writer did not observe such relations for the rocks of Byng Creek region. The summit of the hill at the northern end of the belt of these rocks (6,100 feet elevation) is made up of bedded tuff of the Laberge series. Although the actual contact was not seen it is probable that the rhyolite has an intrusive relationship with these. The acid volcanics were not seen in contact with the Coast Range intrusives. Various stages of devitrification were shown by the thin sections of the rhyolites. This, however, is not considered to be a reliable criterion for age. In the absence of definite evidence, the acid volcanics of Byng Creek region have been correlated on the ground of lithologic similarity with the Wheaton River volcanics in Wheaton district where the field relations have been worked out in greater detail than elsewhere in Whitehorse district. For this reason it is considered best to retain the succession given by Cairnes in which the "acid volcanics" are placed above the basic "newer volcanics" in the geologic column.

## Quaternary Deposits

Extensive and, in places, thick deposits of Quaternary age occur throughout Whitehorse district. These are generally confined to the valleys and lowlands; as a rule they are lacking on the upland surfaces where almost bare consolidated rocks are exposed for many square miles. The Quaternary deposits are of glacial, fluvial, and lacustrine origin, and consist of sand, gravel, soil, silt, clay, boulder clay, and a subordinate amount of volcanic ash. It is believed that the Quaternary deposits of Wheaton district are fairly typical of those in the whole of Whitehorse district.

Certain terraces observed along the sides of valleys in Wheaton district are the subject of a discussion by Cairnes.[1] Theories of their origin advanced by various writers are discussed and their respective merits compared. More or less valid objections to each are set forth. Cairnes considered the most probable theory to be that advanced by Nordenskjold and others which involves a damming of the lower Yukon river.

Terraces were observed by the writer at a number of localities in the eastern part of Whitehorse district. They exist at various elevations, some of them being high up on mountain slopes, as for example in the valley about 1 mile south of mount Juno and to the west of the same peak where there are benches at elevations of more than 4,000 feet. The material constituting the terraces was seen in places to be gravel which has little or no stratification. It seems probable that they are fluvial deposits laid down during a local temporary damming of the waters of streams which later broke through and cut away most of the material, leaving narrow terraces against the sides of the valleys. This theory was advanced by A. H. Brooks and others. Cairnes objects to it on the ground that it "calls for the existence of vast amounts of material over the present valley floors which cannot be true in certain localities including Wheaton district." Insufficient data were obtained to form the basis of any final explanation of the origin of the terraces. On account of the high elevation of many of them above the present level of Lewes river in Whitehorse district it appears improbable that the postulation of a damming of the lower Yukon river is a valid explanation of their origin.

# STRUCTURAL GEOLOGY

Only the major features of the structure can be treated here, as owing to the nature of the work time did not permit of solving the more intricate local structures.

The general trend of formations in Whitehorse district is northwest, with the possible exception of some of the more recent volcanic rocks. This is only a general rule for southern and central Yukon; a glance at the map of Yukon will serve to show that the major features have a similar trend. The Coast range has an alignment along an axis trending northwest, Mackenzie mountains have a similar trend, and Yukon plateau, which is in reality a broad geosyncline, has an axis trending northwest

[1] Cairnes, D. D.: Geol. Surv., Canada, Mem. 31, pp. 21-23.

and marked approximately by the position of Lewes and Yukon rivers. The valley systems as a rule follow two directions, northeast and northwest, with the major streams occupying valleys trending northwest. In other words, the broad, general features are only an expression of rock structure.

Whitehorse district falls naturally into two divisions. In the western part the geology is largely that of the Coast Range batholith. Along the borders of the batholith the plateau surface coincides very closely with the former roof of the batholith and many remnants of the roof are preserved. Older rocks exist as walls separating adjacent parts of the batholith, and in some instances extend as deep as the valleys have cut, and numerous patches of the older rocks occur as inclusions in the batholith. Towards the west these become less numerous as the central part of the batholith is reached, indicating that in that part the roof was higher and suffered more by erosion than along the margins. Passing to the eastward from the main granitic bodies numerous outlying bodies of granite occur. Assuming that these are connected with the main mass, they would show that the granite contact is of undulating character, and that much of Whitehorse district is underlain by granite at depth.

In the eastern part of the district, and more particularly that part occupied by the bedded rocks of the Laberge series, the northwest trend is well marked, but complicated by minor folding. The dips as a rule are steep, and where the strike is regular, their rapid alternation indicates intense folding, probably combined with faulting, for there is a noticeable lack of curved or bent strata among the more competent beds. Incompetent beds are highly contorted.

As the general northwest trend includes formations of pre-batholithic age, the folding may be regarded as the effect of fundamental processes involving large parts of the earth's crust and probably continuing over considerable periods of time, and the northwesterly trend of the batholith may be regarded as following an already established direction of folding. Minor or secondary structures were undoubtedly developed by the stresses accompanying the batholithic intrusion; the development of fissure veins about the borders of the granite mass is in itself sufficient proof of faulting at that period, but on the whole it would appear that folding along a northwesterly trending axis had already been developed.

# CHAPTER IV

## ECONOMIC GEOLOGY

Whitehorse district contains numerous mineral deposits, and coal is also known to occur at several points. Almost all the known mineral deposits have been described from time to time in reports of the Geological Survey, but as these accounts are scattered through many reports, some of which are out of print, the salient features of all the deposits are repeated below.

Though many prospects have been discovered, and though some of these have at times reached the stage of producing mines, the fact remains that at present there is not a single property in Whitehorse district producing ore. Various reasons may be assigned for this condition, but the most important is the lack of cheap transportation. Although the White Pass and Yukon route has, for a number of years, endeavoured to encourage mining by reduced freight rates on ores, these rates still remain a considerable handicap against any ore shipped; and the incoming freight rates on machinery and supplies render the cost of operating in the district excessive. There are no other industries, as in more favoured sections of Canada, to assist in maintaining transportation systems; lumbering and agriculture in Yukon furnish only a minimum of freight, so that the mining industry is practically the sole support of the transportation system, and the volume of business in the past does not warrant the expectation that freight rates can be decreased in the near future.

A number of properties have been worked, some of them none too economically, and from some a considerable amount of the higher grade ores have been shipped. The cost of operating in this way, on a small scale, prohibited proper development of the ore-bodies, with the result that the properties are now less attractive to prospective purchasers than they were when first found.

A third factor which has undoubtedly retarded mining development, is the difficulty of prospecting. Most of the upland surface of the district is covered with superficial deposits that obscure the vein outcrops, and as this superficial material is frozen for most, if not all, of the year, stripping, trenching, and so forth are slow and expensive processes as compared with more southerly districts. It can, therefore, be stated that there are large areas of some promise in Whitehorse district which have been only partly prospected.

### ORE DEPOSITS

The ore deposits of Whitehorse district, for convenience of description, may be divided into four main groups:

*(a)* Gold-silver quartz veins
*(b)* Antimony-silver veins
*(c)* Silver-lead veins
*(d)* Contact metamorphic deposits

## Gold-Silver Veins

These veins are widely distributed in southern Yukon, and occur in Windy Arm and Wheaton areas, Whitehorse district. They occur in a general way in a belt paralleling the trend of the Coast range. The veins occur in the Coast Range intrusives, in the Older Volcanics, and in the schists of the Mount Stevens group. The vein fillings consist chiefly of quartz with subordinate amounts of calcite and barite. Galena is the most characteristic metalliferous mineral. Arsenopyrite, chalcopyrite, stibnite, pyrite, and tetrahedrite are common; rarer minerals include argentite, pyrargyrite, jamesonite, chalcocite, yukonite,[1] native gold, native silver, and tellurides with the usual oxidation products.

### DESCRIPTION OF PROPERTIES

#### *Windy Arm District*[2]

Many claims have been located in Windy Arm district, as that part of Whitehorse district lying between Bennett lake and Windy arm of Tagish lake is commonly called. Much work was done on them prior to 1912; since that time some of the properties have been worked intermittently. At the present time no work is being carried on. The various properties are readily accessible from Carcross on the White Pass and Yukon route, which serves as the centre for the district.

*Big Thing.* The Big Thing is located 5½ miles south of Carcross and is connected with that point by wagon road. The property was worked for a number of years by J. H. Conrad and subsequently taken over, for money advanced, by representatives of Mackenzie and Mann, who still own the property.

The development work includes an inclined shaft of 450 feet, with four levels which total over 700 feet of drifting. An adit 2,320 feet long intended to crosscut the vein at depth was also run, and from this several crosscuts and raises were driven.

The ore deposit is a fissure vein that cuts granitic rocks. It strikes north 55 degrees east and dips northwest from 25 to 35 degrees. It is mostly from 2 to 8 feet thick, although in places it attains a thickness of 12 feet. The mineralization is of quartz with pyrite and arsenopyrite, and subordinate galena, chalcopyrite, and stibnite.

To the east of the shaft the vein is repeatedly faulted; to the west of the shaft where exposed in the various levels it is relatively regular. Cairnes estimated, in 1916, that about 75,000 tons of ore had been practically blocked out, excluding the much faulted parts to the east of the shaft, and estimated an average value of $15 a ton in gold and silver for this ore. It is known that the shipments of ore made since that time have been relatively small, as the mine has been closed down for most of this period.

*Montana.* The Montana is another of the original Conrad properties and is located high on the mountain side 3 miles south of the Big Thing.

[1] An hydrated arsenate of calcium and iron. *See* Johnston, R.A.A.: Geol. Surv., Canada, Mem. 74, p. 240 (1915).
[2] Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1916, pp. 34-44.

The development work includes a drift along the vein for a distance of about 700 feet. An incline shaft was sunk, which for part of its depth follows the vein, but departs from it where the vein changes its dip. A short crosscut has been run from the bottom of the shaft to intersect the vein at that depth.

The vein is a fissure, in volcanic rocks, striking about north 10° 30′ east astronomic and dipping southwest at 10 to 30 degrees. It has a thickness of 2 to 5 feet and is composed mainly of quartz with which is associated galena, pyrite, arsenopyrite, pyrargyrite, argentite, native silver, and lead carbonate. The principal values are in silver, but the pyritic parts also contain gold. In places the vein matter, especially adjoining the walls for thicknesses of 8 to 18 inches, is very highly impregnated with silver minerals and assays $80 to $90 a ton. The rest of the vein is of much lower grade.

*M and M.* The M and M is also one of the original Conrad claims. The vein outcrops on the left bank of Pooly canyon near the top of the hill and has been traced about 400 feet on the surface. It is a fissure in andesite, striking almost due north and dipping west at an angle of 15 degrees. It has a thickness of 6 to 12 inches, and is composed mainly of quartz with which occur pyrargyrite, stephanite, freibergite, tetrahedrite, and carbonates. A small shipment is reported to have yielded $165 a ton in gold and silver, mostly the latter.

*Venus.* The Venus is one of the most extensively developed of the original Conrad properties, and like the others is now controlled by representatives of Mackenzie and Mann. Two claims are included, Venus No. 1 and Venus No. 2; the bulk of the work has been on No. 2. On No. 1 a shaft 52 feet deep has been sunk on the vein and from the bottom of the shafts drifts have been run about 50 feet in opposite directions.

On the Venus No. 2 two adits have been driven which cut the vein at different depths. The upper adit is 80 feet long and encounters the vein at 75 feet below the surface. The lower adit is 600 feet long and cuts the vein at 263 feet below the level of the upper adit. From the upper adit, drifts have been run 108 and 88 feet to the south and north, respectively. From the lower adit drifts have been run 583 and 622 feet to the south and north, respectively. Several raises and stopes have been driven from this lower level, and two winzes 235 and 400 feet deep have been sunk from the north and south drifts.

The vein is a fissure cutting andesites and has a strike of north 10 degrees east and a dip to the west ranging from nearly flat to 60 degrees. The fissure is in most places of a compound nature, and the vein as a whole is confined between two main fault-planes from a few inches to 8 or 9 feet apart. The ore material averages from 2½ to 3 feet thick, and consists of quartz, galena, pyrite, and arsenopyrite, with jamesonite, yukonite, chalcopyrite, and chalcocite, as well as oxidation products. The gold value rarely exceeds $50 a ton and is generally under $25; the silver values vary from less than an ounce to 100 ounces to the ton. The ore in the higher grade shoots averages from $30 to $50 a ton in all values, but much of the vein is low grade, running from almost nothing to about $20 a ton.

*Dail and Fleming Group.* A number of claims generally known as the Dail and Fleming group are situated immediately south of the Venus. These include the Venus Extension, Red Deer, Humper No. 1 and No. 2, Nipper No. 2, and Beach. These claims have been divided into two groups, the Venus Extension group, owned by I. E. Fleming and John Miller and including the Venus Extension, Red Deer, and Humper No. 1; and the Humper group, embracing the balance of the claims, owned by John Miller and Mrs. M. Watson.

The development work includes an incline shaft 120 feet deep on the Venus Extension, a crosscut and drift of 205 feet on the same claim; a crosscut and winze on the Nipper No. 2; a winze and drift on the Humper No. 2 and a number of open-cuts and pits.

Three principal veins have been found. These are known as the Venus, Humper, and Red Deer. The Venus vein is the same as the one developed on the Venus property, and has been traced entirely across the Venus Extension. Its characteristics are somewhat similar to those given for the Venus property, save that the attitude of the vein is nearly flat, and the vein is intensely leached and oxidized.

The Humper vein, also, occurs in a fissure traversing andesitic rocks. The strike varies from east and west to north 60 degrees east and the dip from 35 degrees to 65 degrees to the north and northeast. The thickness of the vein is from 10 to 24 inches. The vein is composed of quartz with which are associated argentite, pyrargyrite, stephanite, galena, pyrite, and some native silver.

The Red Deer vein, also a fissure in andesite, strikes north 30 degrees east and dips northwest at an angle of 50 degrees. It is, where exposed, from a few inches up to 3 feet in thickness, and is composed of quartz which carries pyrite, galena, and various high-grade silver minerals.

### *Wheaton District*[1]

Most of the properties of Wheaton district are readily reached from Robinson station on the White Pass and Yukon route, from which point a wagon road leads to Carbon hill, passing within short distances of the majority of the properties described.

The Wheaton deposits occur in a belt 16 miles long and 9 miles wide, and the majority of the deposits lie in the central strip of this belt, 2 miles wide and extending from mount Stevens across Gold hill and Hodnett mountain. Other veins have been found on mount Anderson and Red ridge to the west and east, respectively, of this 2-mile belt. The majority of the veins strike, in a general way, parallel to the belt in which they occur; this belt parallels the trend of the Coast Range mountains to the west. The veins are as a rule steeply inclined, with a prevailing easterly dip.

The deposits occur chiefly in the Coast Range intrusives, but also exist in the schistose members of the Mount Stevens group. The veins in the intrusives are regular in strike, thickness, and mineral composition for considerable distances. One has been traced 3,000 feet and has 4 or

[1] Cairnes, D. D.: "Wheaton District"; Geol. Surv., Canada, Mem. 31, pp. 87-113 (1912).
Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1922, pt. A, pp. 1-8.

5 feet of vein material over this distance. How far the other veins extend is not known, but some have been traced for 1,500 feet. They vary in thickness from a few inches to 7 or 8 feet, but the average vein in the granite is 3 or 4 feet thick. In the schist the materials have been deposited in lens-shaped masses, or in irregular fissures which may connect these lenses or be independent of them. The lenses are mostly 6 or 8 feet thick and 20 to 40 feet long. One lens on the Acme claim is 30 feet wide and 100 feet long.

The vein fillings consist of quartz with subordinate amounts of calcite. Galena is the characteristic metalliferous mineral. Pyrite, chalcopyrite, native gold, sylvanite, hessite, petzite, and telluric ochre also occur.

*Mount Stevens.* The Acme claim, owned by O. Dickson, is situated on top of mount Stevens. The vein consists of a lenticular mass of quartz which occurs in chloritic or sericitic schists and is 30 feet wide at one place, and appears to be about 100 feet long. In some places galena and pyrite occur, but the bulk of the quartz contains no metalliferous minerals.

The *Buffalo Hump Group*, owned by G. Stevens, consists of three claims, the Sunrise, Golden Slipper, and Wheaton. On the Golden Slipper claim a certain amount of quartz float carries disseminated galena with free gold and sylvanite. The vein from which this material came has not yet been discovered.

On the Sunrise claim, a quartz vein, in a fissure in granite, carries some galena and native gold. The vein is 7 feet thick in one place; but does not average more than 2 or 3 feet for the 50 feet that the ore has been traced. The values are very erratically distributed.

*Midnight Group.*[1] The Midnight group is situated on the southeastern face of Stevens mountain, and consists of eight claims, owned by M. Watson and E. Johnson, of Carcross.

The veins are in reality dykes of granite porphyry which have been altered and silicified. The infiltration of secondary silica was accompanied by the deposition of native gold, galena, and pyrite. Two main dykes have been recognized, one 50 feet wide and the other 25 feet wide. A rough sampling of the property indicated that the values are spotty and not maintained over the width of the dyke, but are confined to the places where gold or sulphides are visible. A considerable amount of surface work has been done on the deposits.

*Wheaton Mountain.* The McDonald Fraction, situated near the western edge of Wheaton mountain, has a vein cutting granite and striking north 47 degrees west. Its dip is nearly vertical. The vein is well mineralized, chiefly with argentiferous galena, which in places constitutes the greater part of the vein filling. A 20-foot shaft has been sunk on the vein. A number of samples taken from the vein and from the dump at the shaft all assayed less than $1 a ton in gold and silver.

The Silver Queen and Gopher claims are situated on the western part of Wheaton mountain and are the principal claims in a group of seven owned by C. I. Burnside, Adam Birnie, C. J. Irvine, and others. On the Silver Queen is a quartz vein in granite, about 3 feet thick, which contains galena and pyrite. On the Gopher, is an irregular, lenticular mass of

[1] Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1922, pt. A, pp. 6-7.

quartz in greenstone schist, which at its widest point is 7 feet from wall to wall. The quartz carries scattered particles of galena.

*Tally-Ho Gulch.* The Tally-Ho group is situated on the west side of Tally-Ho gulch and includes eight claims, the property of C. J. Irvine, C. I. Burnside, Adam Birnie, and others.

The ore occurs in a brecciated fault zone 4 to 12 feet thick cutting granitic formation. The zone strikes northwest and dips to the northeast at 60 to 70 degrees; a drift has been run along it 290 feet, leading from which are a 40-foot raise and a 15-foot crosscut.

The granitic fragments of the fault breccia have been cemented by quartz, and a vein of quartz of varying thickness has been deposited along the foot-wall. The quartz carries considerable galena and from $9 to $80 a ton in gold and silver. It is thought that a considerable percentage of the quartz will average $20 to the ton in gold and silver.

Since the most recent examination of this property it has been reported that the claims were under option. A considerable amount of work has been done under the direction of C. J. Irvine, but details are not available.

*Mount Anderson, Whirlwind, and Sheep Mountain Groups.* These groups consist of six and five claims, respectively, and are owned by Theodore Becker and H. Cochran. Two main veins have been discovered on the property, and extend along the face of mount Anderson for a distance of 2,000 feet or more. The greater part of the development work has been done on the lower vein. A drift 350 feet long has been run on this vein, which over this distance has an average thickness of 18 inches, and a maximum thickness of 6 feet. About 150 feet below this drift, a crosscut 172 feet long has been driven to the vein and a drift from the end of the crosscut follows the vein for 150 feet. Over this distance the vein has a thickness of 18 to 20 inches.

Continuing to the southeast along the face of mount Anderson vein outcrops have been exposed by surface workings for a distance of 2,000 feet. These may be parts of two or possibly three additional veins, but are more likely the continuation of the lower vein repeatedly faulted. On the Sheep Mountain group, the most southerly exposure is termed by the owners the "big showing." The quartz here has an aggregate thickness of 3½ to 4½ feet and is well mineralized.

The lower vein is claimed to average $10.60 a ton in gold, silver, and lead; the lead running 8 per cent and valued at the rate of 4 cents a pound. The gold is mostly low, but occasional samples have carried 3 ounces to the ton.

Approximately 200 feet in elevation above the outcrop of the lower vein, an upper vein outcrops. This strikes about due east and is nearly vertical. The vein consists of quartz with disseminated galena and pyrite. An adit 35 feet long has been run to crosscut the vein, and a drift 75 feet long has been run in a southerly direction from the end of the adit. The vein as exposed has a thickness of 4 to 20 inches, and samples taken from it at close intervals contained $5 to $18 a ton in gold, silver, and lead.

*Gold Hill and Vicinity.* The Gold Reef claim is situated on Gold hill. The vein strikes north 55 degrees west and dips southwest at 50 to 60 degrees. It occurs in greenstone schist and is one of the most regular of the veins so far found in the schistose formation. It has been traced for

1,000 feet and has an average width of 4 to 5 feet. The quartz, with the exception of occasional particles of pyrite, contains practically no metalliferous minerals. A few pockets of ore have been found, however, containing native gold, sylvanite, hessite, petzite, and telluric ochre. Although considerable development work was done less than a ton of this rich ore has been discovered.

The Legal Tender is the only other claim in this locality on which development work has been done since 1906. This claim lies on Mineral hill overlooking Watson valley. The vein is a fissure in granite, and strikes in a northwesterly direction and its attitude approaches the vertical. The fissure is filled with quartz and argentiferous galena, with occasional masses of chalcopyrite. A drift 100 feet long has been run on the vein, which for this distance remains fairly persistent in strike, dip, thickness, and degree of mineralization.

*Mount Reid Property.*[1] Two claims, the property of A. Birnie and C. I. Burnside, have been staked on the eastern slope of mount Reid.

The vein is only partly exposed in a small gulch, tributary to Skukum gulch, and has been traced on the surface for a distance of 1,000 feet by means of pits, most of which had caved at the time of examination. The gangue of the vein is quartz, mineralized with galena, pyrite, stibnite, and arsenopyrite. At the only point where exposed the vein had a thickness of 3 feet.

*Mascot Group.*[2] This property is situated on a small gulch near the head of Watson river. The group is owned by M. Watson and E. Johnson of Carcross.

The development work consists of an adit 200 feet long, which, however, could not be examined in 1922 as it was filled with water and ice. The outcrop of the vein is visible along a cliff face for nearly 2,000 feet. Assays from the outcrop show values of $15 to $30 in gold, silver, and lead. Below the adit the vein is 6 feet wide, but, inside the portal, it narrows to 2 feet, and according to information supplied, to 6 inches at the face.

### GENESIS

Cairnes shows that if these gold-silver quartz veins of Windy Arm and Wheaton districts are connected with the intrusion of igneous rocks, they must belong to the period of intrusion of the Coast Range granites; for they cut these granites, and are older than all the igneous rocks of the district, which are themselves newer than the granitic intrusives. In the field the veins are everywhere intimately associated with these granitic rocks. The solutions depositing the ores traversed the fractures in the outer, cooler parts of these granitic rocks, while the interior of the granitic mass was still in a highly heated condition.

## Antimony Silver Desposits[3]

The area containing these deposits is limited, so far as is known, to the eastern face of Caribou hill and part of Chieftain hill, Wheaton district.

[1] Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1922, pt. A, pp. 5-7.
[2] Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1922, pt. A, pp. 5-7.
[3] Cairnes, D. D.: "Wheaton District"; Geol. Surv., Canada, Mem. 31, pp. 113-129 (1912).

The deposits are of the fissure vein type, the fissures occurring in the Coast Range intrusives and the andesites and volcanic breccias of the Older Volcanics.

Two of the veins have been traced for distances of 2,000 feet; but other outcrops are rather commonly covered with superficial materials, and none of them has been followed for more than 200 feet. The veins vary in thickness from 2 or 3 inches to 6 feet, but 1 to 3 feet is about the average of the more valuable. Stibnite constitutes the greater part of the vein fillings in some parts of the veins, and in such cases is associated with minor amounts of sphalerite and jamesonite. Where any gangue is present it is as a rule quartz; barite and calcite occur only in subordinate amounts. The veins that are richest in silver consist of a quartz gangue, impregnated with galena and tetrahedrite, and a small amount of antimony minerals. In fact, ores that are high in silver are mostly low in antimony and vice versa; but there are places where silver and antimony occur together in considerable amounts. Assays running over 500 ounces of silver to the ton have been obtained, but they are exceptional, and most of the ores of the better grade, carrying galena and tetrahedrite, run from 100 to 200 ounces of silver a ton. The higher grade stibnite ores carry from 50 to 65 per cent antimony.

## DESCRIPTION OF PROPERTIES[1]

### *Chieftain Hill and Vicinity*

The only vein of any importance known on Chieftain hill is exposed in a prominent draw, about half-way to the summit. Two claims, known as the Morning and Evening claims, were formerly located on this deposit, but these have since lapsed and been relocated. The cuts, trenches, and pits made on these claims have all filled in, but the vein is visible where it crosses the gulch and there has a thickness of 5 feet. The vein consists chiefly of quartz and stibnite, with subordinate amounts of zinc blende; 2 feet of this thickness is composed almost entirely of stibnite. The vein narrows rapidly in each direction from this point, being not more than 6 inches to a foot in thickness 50 feet away.

### *Carbon Hill*

*Fleming Property.* A group of six claims on the western face of Carbon hill is owned by W. J. Fleming of Chicago. They include the claims formerly known as the Porter group.

A number of veins have been discovered on this property, the exact number being uncertain due to the fact that in some cases not enough work has been done to permit of correlating parts of veins. The veins occur cutting Coast Range granitic intrusives and andesites of the Older Volcanic group. The development includes 1,100 feet of underground workings. The veins range from a few inches to 3 feet in thickness, but are generally under 2 feet thick. Average samples of the vein material rarely carry more than 20 to 25 per cent antimony, and in most cases less than 20 per cent. The gold content is mostly less than $1 a ton. The

[1] Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1915, pp. 47-49.

silver and lead values are, however, important. The better veins contain from 15 to 30 ounces of silver to the ton, with occasional assays of 50 ounces. The average silver content for all the veins is somewhat less than 5 ounces. Lead in average samples is in most cases under 5 per cent.

*Goddell's Claims.* These claims occur on the Wheaton River slope of Carbon hill, about a mile north of the Fleming group. They are believed to be the property of C. Goddell.

Two parallel veins, 20 to 30 feet apart, outcrop in a gulch on these claims, and are distinctly exposed, extending up the mountain side for 2,000 feet. They cut Coast Range granites, and strike north 83 degrees west and are almost perpendicular. The veins consist of quartz impregnated with jamesonite and arsenopyrite, and are from 2 to 6 feet thick.

*Becker-Cochran Property.* This claim is situated on the eastern side of Carbon hill, and is owned by Theodore Becker and Howard Cochran. The vein has a thickness of possibly 3 feet, but as it had not been stripped when visited very little definite information was available. Samples taken from the vein float indicated 21 to 40 per cent of antimony and no silver.

#### AGE OF THE VEINS

Some of the veins occur in the Mesozoic andesites and in a few places the veins are cut by the Newer Volcanics. They consequently antedate the late Tertiary, and are more recent than the andesites of Jurassic or Cretaceous (?) age.

#### GENESIS

The minerals present and the textures of the ore all indicate that the ores belong to the upper vein zone. Cairnes postulates a connexion between these veins and the igneous rocks that occur in the vicinity and argues that the materials composing the veins were deposited in the granitic rocks and already cooled andesites and breccias, while the underlying magma from which these rocks were derived was still hot or molten. He points to the probability that the Older Volcanics and Coast Range granitic intrusives were derived from a common magma. As it has since been proved that the Older Volcanics are earlier than the Coast Range intrusives, the view that these deposits owe their origin to the magma of the Coast Range intrusives may be accepted, and it would appear that the underlying parts of this magma remained in a highly heated condition for a considerable period.

### Silver Lead Veins[1]

Although silver-lead veins are treated as a separate group, it will be seen that they possess many points in common with the gold-silver-quartz type, and that the division between the two classes is not very sharp. Portions of some of the deposits considered under the head of gold-silver quartz veins are valuable chiefly for their silver and lead content. The deposits considered below, however, have certain characteristics which have caused them to be considered as a separate group.

[1] Cairnes, D. D.: Geol. Surv., Canada, Mem. 31, pp. 129-140 (1912). Geol. Surv., Canada, Sum. Rept. 1915, p. 49.

Veins of this class occur on Idaho hill and mount Follé in the arkoses of the Laberge series. The deposits are tabular in form, but there is a lack of definition between the walls and the ore. The veins are exceedingly irregular in thickness, ranging from a few inches up to 4 to 6 feet.

The vein materials consist chiefly of quartz, calcite, galena, arsenopyrite, zinc blende, pyrite, and chalcopyrite. Quartz is the chief gangue mineral, and arsenopyrite and galena are the principal sulphides. The ores generally contain only a few cents to the ton in gold, and rarely have more than $2. Assays of better-grade ores yielded approximately 50 ounces of silver and 40 per cent lead.

### DESCRIPTION OF PROPERTIES

*Union Mines.* The property known as Union Mines consists of two claims owned by Messrs. Schnabel and Northop. It is many years since any work has been done on these claims.

Twelve veins have been found. One of these is, where exposed, 2½ feet thick. The others, throughout the greater part of their lengths, vary in thickness from 4 to 12 inches, but in a few places masses of ore ranging, with included rock, from 2 to 4 feet thick and from 5 to 20 feet long, were found. One irregular area, possibly 12 feet wide and 20 feet long, appeared to be half ore. The majority of the veins strike about north 12 degrees west and dip 60 to 70 degrees to the southwest.

*Nevada Mines.* This group of eight claims is owned by C. Bush and W. F. Schnabel, and was located as an extension to the Union Mines group. Only two veins are exposed on the Nevada group; these are similar to those at Union mines except that they contain much less galena, and so consist mostly of quartz, calcite, arsenopyrite, zinc blende, pyrite, and chalcopyrite.

### GENESIS

Cairnes cites evidence to show that the deposits of Union mines and Nevada mines are metasomatic replacements of arkoses of the Laberge series, and that the solutions travelled along the bedding planes of the clastic rock, filled with ore minerals any small spaces that may have existed, and replaced the rock material on either side.

The source of the ore-bearing solutions is unknown, but they are believed to be connected with the intrusive rocks of the locality. As the age of the deposits is not known except that they are later than the Jurassic Laberge series which contains them, it is difficult to state to which period of vulcanism they belong. It is known, however, that the Coast Range intrusives are responsible for the greater part of the mineralization of Whitehorse district, and it is possible that the formation of these silver-lead deposits is also due to the intrusion of the Coast Range batholith. More detailed mapping of Wheaton district has shown the probability of these rocks extending below the mineralized area at no great depth.

## Contact Metamorphic Deposits

Almost all the deposits belonging to this type occur within the Whitehorse copper belt, which extends 12 miles along the valley of Lewes river from a point east of Dugdale northwestward to the base of mount Hackel. One deposit in Wheaton River district also falls within this class.

### *Whitehorse Copper Belt*[1]

The ore deposits occur chiefly at or near the contacts between limestone and granitic intrusives, deposits being found both in the limestone and in the granite.

The principal economic minerals of the district are the two copper sulphides, bornite and chalcopyrite. Tetrahedrite occurs at the Arctic Chief and small bunches of chalcocite at the Best Chance and other places. Oxidation products are abundant and except at the Pueblo are seldom important as ores. They include the carbonates malachite and azurite, the oxides cuprite and malaconite, and the silicate chrysocolla. Native copper is in some places associated with the cuprite.

Iron sulphides are not abundant and nowhere form large masses. Scattered grains of pyrite occur in the granites and altered limestones, and pyrrhotite occurs at the Arctic Chief.

The iron oxides, magnetite and hematite, are widely distributed. Magnetite is specially abundant and lenses of this material from a few inches to 360 feet in length are found all along the belt, mostly in the altered limestones, but also in the altered granites. Hematite is less common, but is the principal mineral in the Pueblo deposit.

Other metallic minerals of less frequent occurrence are arsenopyrite, stibnite, galena, sphalerite, and molybdenite. Gold and silver occur in all the ores. Both are occasionally found as native minerals.

The principal non-metallic minerals accompanying the ores are garnet (andradite), augite, wollastonite, actinolite, epidote, calcite, clinochlore, serpentine, and quartz.

The ore-bodies fall into two classes; those in which the copper minerals are associated with magnetite and hematite and those in which silicates are the chief gangue minerals. The magnetite ore-bodies are numerous and occur enclosed completely in altered limestone, or along the lime-granite contact, or in the altered granite. The largest bodies discovered are the Best Chance 360 feet in length, Arctic Chief 230 feet, and Little Chief 100 feet. The magnetite masses are always sprinkled with grains and masses of bornite and chalcopyrite. Hematite masses are much less common than magnetite, only one large body being known. This is the Pueblo lode. It differs from the magnetite ore mainly in the greater oxidation of the copper minerals.

Showings characterized by silicate gangue are numerous wherever the lime-granite contact is exposed. These vary from a sprinkling of copper minerals to lenses of considerable size such as are developed on the Grafter,

[1] McConnell, R. G.: "Whitehorse Copper Belt"; Geol. Surv., Canada (1909).

Copper King, War Eagle, and Valerie. All the important bodies of this class occur in the limestone, close to the granite, and are in many cases separated from the granite by a zone of more or less completely replaced limestone.

As practically no geological work has been done on these deposits since the report by McConnell, descriptions of the individual deposits need not be given here. At some of the properties considerable mining has been done since the date of McConnell's report, and as in many cases the workings are inaccessible, due to the fact that the properties have been shut down for a number of years, it is felt that any description based on McConnell's report would be considerably out of date. In 1907 McConnell estimated the ore in sight, as a result of the development then performed, amounted to about 500,000 tons. In 1915 Cairnes[1] stated that of this not over 100,000 tons had been removed, and that a number of important ore-bodies, not known when McConnell made his examination, had been discovered. Since 1915 comparatively little mining has been done in the Whitehorse belt. It is, therefore, to be expected that a considerable tonnage still remains to be extracted, if the occasion should arise when economic conditions would render the mining of the Whitehorse ores profitable.

### *Fleming Claim*[2]

The Fleming claim is situated on a small ridge facing Wheaton river about a mile west of Becker creek and is owned by W. J. Fleming and H. E. Porter.

The ore materials occur in a hornblende gneiss of the Mount Stevens group, close to the contact between the gneiss and the Coast Range granodiorite. The deposits follow the strikes and dips of the gneisses, trending north 42 degrees west and inclined at 60 to 90 degrees in either direction.

The largest deposit is 30 feet wide with length unknown; near this are two smaller bands 4 to 6 feet wide. The mineral deposits consist of magnetite, specular hematite, chalcopyrite, pyrite, quartz, calcite, epidote, actinolite, and garnet, apparently grossularite. The central part of the large deposit consists chiefly of iron and copper and contains about 1 per cent copper. Gold does not exceed $2 a ton.

## Metallogenetic Epochs

All known ore deposits of Whitehorse district have probably formed later than the intrusion of the Coast Range batholith. This intrusion probably took place in late Jurassic time and possibly continued through a part of Lower Cretaceous time. Two contrasting types of deposits occur, contact metamorphic and hydrothermal, respectively.

why later

[1] Cairnes, D. D.: "Economic Possibilities of Yukon"; Can. Inst. Met., Trans., vol. XVIII, p. 63 (1915).
[2] Cairnes, D. D.: Geol. Surv., Canada, Mem. 31, pp. 140-145 (1912).

| Deposit | Occurrence | Mineral association |
|---|---|---|
| Antimony-silver......... | In Coast Range intrusive rocks and in Chieftain Hill andesites and volcanic breccias | Gangue chiefly *quartz;* barite and calcite subordinate *Stibnite*, sphalerite, jamesonite, arsenopyrite, grey copper |
| Gold-silver.............. | Chiefly in Coast Range intrusives, also in schists of Mount Stevens group. Occur as fissure fillings | *Quartz*, calcite, galena, pyrite, chalcopyrite (rare), gold, sylvanite |
| Silver-lead.............. | In Laberge rocks, as metasomatic replacements. Geodes and vugs common | *Quartz*, calcite, *galena*, *arsenopyrite*, sphalerite, pyrite, chalcopyrite |
| Contact metamorphic... | At contact of Coast Range intrusives with country rock, chiefly limestones | Magnetite, specularite, chalcopyrite, pyrite, quartz, calcite, epidote, actinolite, garnet, wollastonite, limonite, azurite, and malachite occur in oxidized zone |

NOTE. Minerals whose names are in italics are abundant.

The contact metamorphic deposits are chiefly confined to a narrow belt about 15 miles long, parallel to Lewes river in the vicinity of Whitehorse. The larger aggregates of metallic minerals occur in limestone or along the contact of limestone and granitic rocks, but numerous small bodies and scattered grains are found wholly enclosed in granite and many are at a considerable distance from the limestone. The development of non-metallic minerals is probably greater in the granite than in the limestone, and the areas affected are wider and more extensive. In places the original contact is completely obscured, owing to the replacement of both rocks by similar minerals. The extensive and simultaneous mineralization of both the intruding and intruded rock may be explained by assuming that it was effected by hot solutions moving upward and that it took place after magma had solidified to some depth. The replacement of ore material of granitic dykes connected with the main granite area is also significant in this connexion.

Contact metamorphic effects such as the marmorization and silicification of limestone were noted by the writer at various points in the eastern half of Whitehorse district, but nowhere were associated deposits of metallic minerals in evidence. The only other ore deposit of this type known in the area is that situated on the Fleming claim in Wheaton district. The ore materials occur in hornblende gneisses of the Mount Stevens group (possibly of Precambrian age) near their contact with the Coast Range intrusives.

It is clear from the published data that there has been a period of mineralization in Whitehorse district closely following the intrusion of the Coast Range granodiorites. Ores of the resulting type are generally supposed to have been intruded under conditions of high temperature and high pressure and in this respect contrast strongly with the other types of ore deposit in the region. The available evidence points to a late Jurassic or early Cretaceous age for the intrusion of the granodiorite, and hence it may be concluded that this first metallogenetic epoch also belongs in the Upper Jurassic.

The ore deposits of Whitehorse district, other than the contact metamorphic deposits, have been classified by Cairnes into three divisions, gold-silver, antimony-silver, and silver-lead veins. Of these, the first class is "of wide distribution in southern Yukon and constitutes the major portion of the ore deposits, not only of Wheaton district but also of Windy Arm district to the southeast."

The genesis of these three types of vein deposits has been discussed by Cairnes in his memoir on the Wheaton district. The conclusions reached are: (1) that they have all been deposited by ascending hydrothermal solutions emanating from an intrusive magma below; and (2) that they belong in the "upper vein zone," that is, they have been deposited under conditions of relatively low temperature and pressure. These conclusions are based on: (1) mineral associations; and (2) the fact that the wall-rock is altered only slightly.

From the evidence so far accumulated the exact geological age of the formation of the three types of vein deposits cannot be definitely determined. That they are of considerably later age than the contact metamorphic deposits seems to be in little doubt. They are younger than the period of solidification of at least a part of the granitic magma, and they antedate the eruptions grouped under the head of Newer Volcanics. This evidence tends to show a late Jurassic to early Tertiary age for these deposits, and depends upon the length of time required for the cooling and solidification of the batholith. That the interior of the batholith remained in a heated and fertile condition for a considerable period of time there can be little doubt. The three different types may or may not be contemporaneous; a simultaneous origin can well be presumed by ascribing their distribution in zones to differences in the parent magma, a case of magmatic segregation.

The distribution of ore deposits in Whitehorse district shows the significant fact that they are all close to the borders of areas of granitic rocks. This fact should be borne in mind in future prospecting work in Whitehorse district. The accompanying map (No. 2071) shows the position of these granitic bodies, and should be of use in prospecting work. The map is somewhat generalized, and this should be recognized in order that the utmost use may be made of it. Particular attention was paid in the field to bodies of granitic rocks, and it is believed that few bodies of any size are not represented on the map. However, the map places at the disposal of the prospector geological information which has taken many field seasons to collect, and which it is hoped will prove valuable as an aid to future mining development.

## COAL[1]

Coal has been found at two localities in Whitehorse district. Only a very little mining has been done, chiefly on account of lack of market.

[1]Cairnes, D. D.: "Report on a Portion of Conrad and Whitehorse Mining Districts"; Geol. Surv., Canada, pp. 20-21 (1908).
"Wheaton District"; Geol. Surv., Canada, Mem. 31, pp. 145-147 (1912).

*Whitehorse Coal*

A number of claims known as the Whitehorse coal claims have been located at the head of Coal creek, near Granger mountain. A tunnel about 60 feet long has been run on one of the seams and a few open-cuts have been made; otherwise the coal is practically undeveloped. The strike of the seam at the tunnel is north 63 degrees west with a dip of 42 degrees to the northeast. The seams measured were 9 feet 8 inches, 10 feet 4 inches, and 2 feet 6 inches. It is probable that a number of other seams, as yet undiscovered, exist. The coal is anthracitic in character—no seams of coking coal were found. Four samples were taken: A, B, C, of the seams in the order mentioned, and D, a sample of a seam found in the creek below the workings, which may be the same as one of the others. The proximate analyses follow:

| Sample | A | B | C | D |
|---|---|---|---|---|
| Water | 2·15 | 3·78 | 3·76 | 2·35 |
| Volatile combustible matter | 6·10 | 10·06 | 8·34 | 6·65 |
| Fixed carbon | 69·86 | 38·38 | 62·50 | 42·27 |
| Ash | 21·98 | 47·48 | 25·40 | 48·73 |
| | 100·00 | 100·00 | 100·00 | 100·00 |

*Mount Bush*

Three seams of coal were partly stripped at the outcrop on mount Bush, Wheaton district, and the outcrops of what appeared to be several other seams were noted. The seams stripped occur in the Tantalus conglomerates, and were 18 inches, 6 feet, and 5 feet thick. At this place the coal measures are intersected by a fault with a displacement of at least 5,000 feet, which will cut off the seams at a depth of 2,000 feet from the discovery, measured along the seams. The coal is a semi-anthracite. The high ash content in the following analysis is probably due to the fact that the sample was taken from the frozen outcrop and contained a high percentage of sand and other materials. The following sample was taken from the 6-foot seam.

| | Per cent |
|---|---|
| Moisture | 4·78 |
| Volatile combustible matter | 8·62 |
| Fixed carbon | 56·50 |
| Ash | 30·10 |
| | 100·00 |

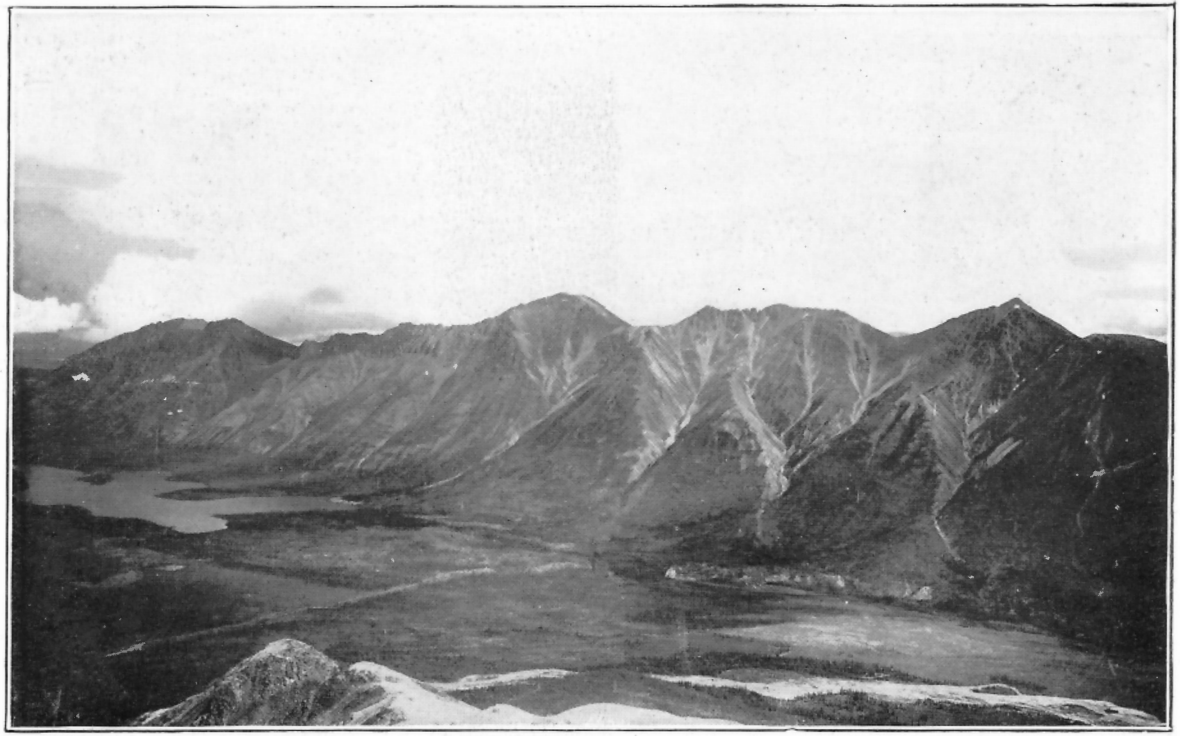
PLATE II

Looking west from mount Pugh toward the Coast range. The gently rolling character of the upland is well seen, as it gradually increases in elevation and finally merges with the more rugged mountain to the west. (Page 3.)

PLATE III

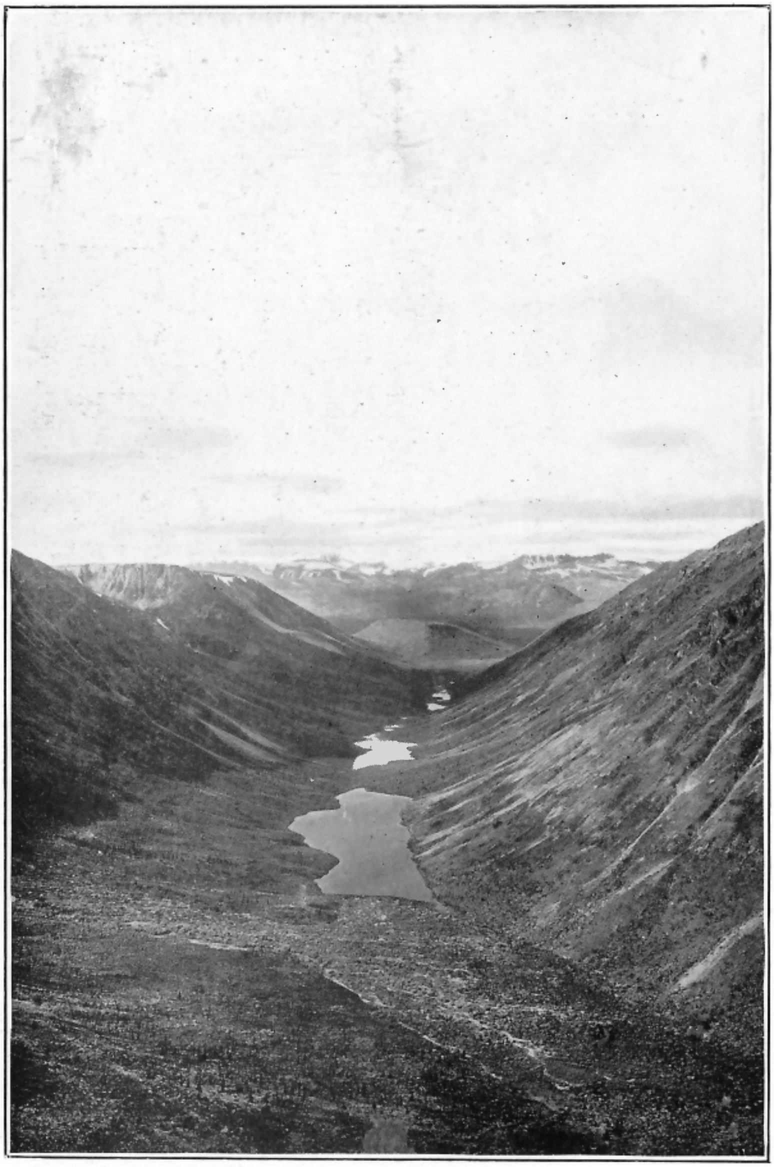
Looking southeasterly down Wheaton River valley toward Big Bend. The view shows the pronounced U-shaped form of the master valley, the even character of the upland surface, and the striking topographic unconformity at the top of the valley wall. (Page 4.)

PLATE IV



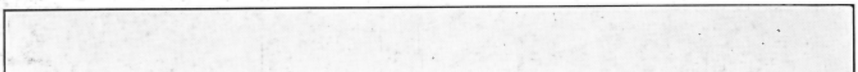
Looking easterly across Corwin valley and Annie lake at the western end of Gray ridge. The view shows the steep character of the valley walls with their pronounced facets, due to glacial truncation of marginal spurs, and post-glacial dissection by small tributary streams. (Page 4.)

PLATE V



Looking westerly up Hodnett Lakes valley. The U-shaped form of the valley, and the unorganized character of the drainage are well shown. (Pages 3, 4.)

A. View of the Coast range from the head of Watson river. (Page 3.)

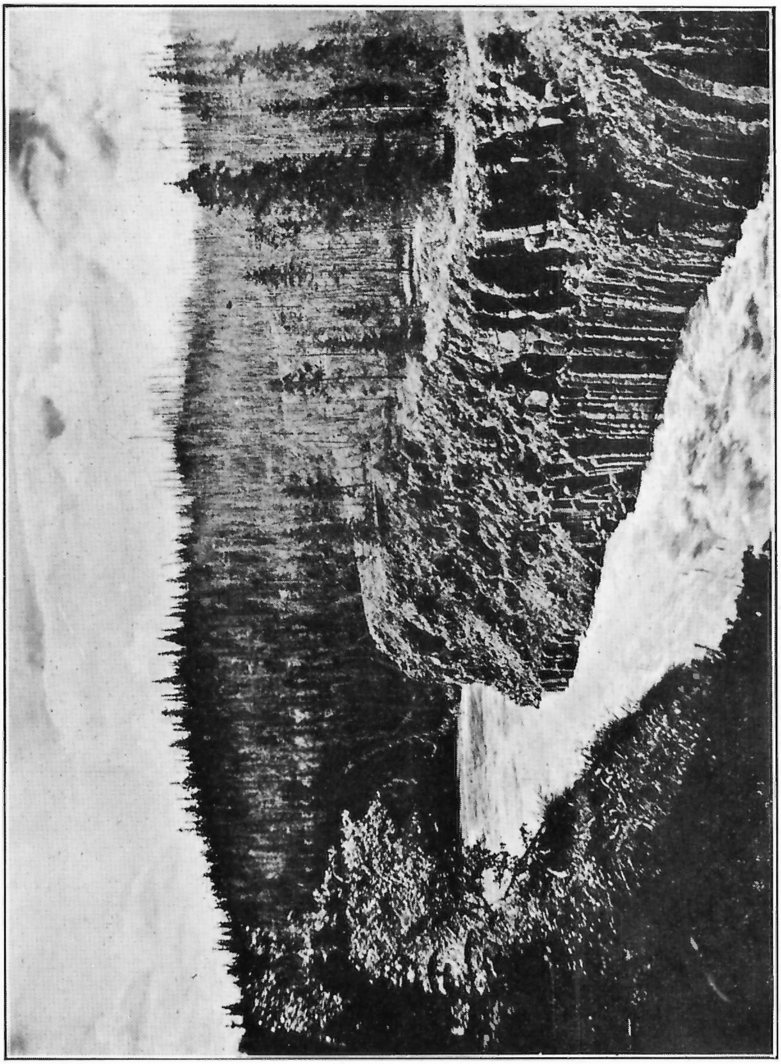


B. A terminal moraine near the head of Fish lake. (Page 4.)

PLATE VII

Limestone bands in Mount Stevens group. The summits are composed of flows of "Newer Volcanics." (Pages 9 and 35.)

Plate VIII



Miles canyon, Lewes river. A cutting in basalts, the jointing of which can be clearly seen. (Page 33.)

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