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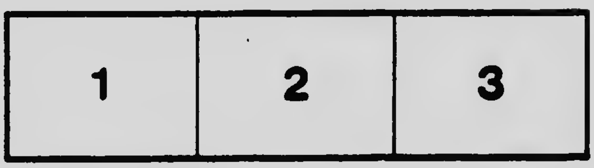


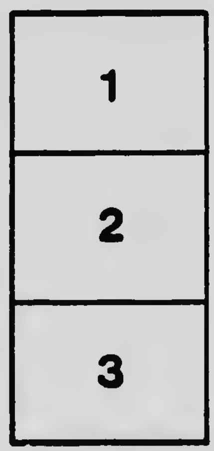


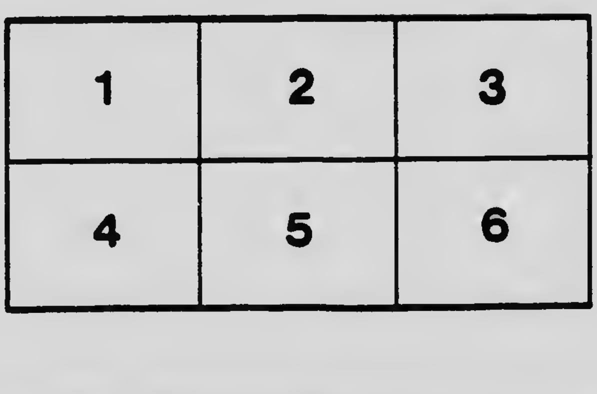

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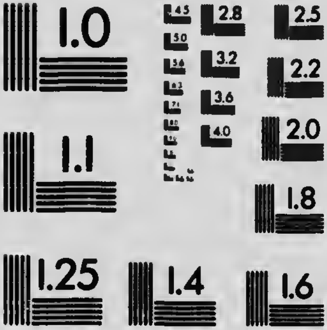


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DEPARTMENT OF MINES

GEOLOGICAL SURVEY BRANCH.

HON. W. TEMPLEMAN, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, DIRECTOR.

# THE

# WHITEHORSE COPPER BELT

## YUKON TERRITORY

BY

R. G. McCONNELL

OTTAWA

PRINTED BY C. H. PARMELEE, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY

1909

No. 1050

*Frontispiece*


Town of Whitehorse.

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No. 1050

R. W. BROCK, Esq.,
Director Geological Survey Branch,
Department of Mines.

SIR,—I beg to submit the following report on the geology and mineral resources of the Whitehorse district. The work on which the report is based occupied four months of the field season of 1907.

The excellent topographical map which accompanies the report is compiled from surveys made by Mr. F. H. MacLaren during the same season.

I was assisted in the field by Mr. H. M. Haughton, and the microscopic examination of the rock sections was also entrusted to him.

My thanks are due to Mr. R. A. A. Johnston, of this office, for assistance in determining the mineral species; to Mr. Robert Smart, territorial assayer, Whitehorse, for several ore analyses, and also for much general information regarding the grade of the ores; to Mr. H. G. Dickson, D.L.S., for surveys of mining claims; and to Mr. Robert Lowe, Mr. Elmendorf, Mr. Byron White, and numerous other mine owners and managers, for assistance and information.

The present report gives a general description of the larger features of the district, but can scarcely be regarded as more than a preliminary one. The country is heavily drift covered, is almost impassable in places from fallen timber, and the work of delimiting the tangled rock areas proceeded slowly, especially as no detailed topographis map was available until one had been compiled, and which occupied most of the season. Further work of a more detailed character, in this important and extremely interesting district, is advisable when practicable.

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

R. G. McCONNELL.

GEOLOGICAL SURVEY OFFICE,
May 12, 1908.

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ON THE

# WHITEHORSE COPPER BELT

## YUKON TERRITORY

BY

R. G. McCONNELL.

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## HISTORICAL.

The history of the Whitehorse copper belt dates back to the early Klondike rush. Discoveries of copper croppings are reported to have been made by miners on their way to Dawson in the summer of 1897. The discoverers were hunting at the time, and the croppings were not located.

The credit of staking the first claim is due to Jack McIntyre, who located the Copper King, July 6, 1898. The Ora, a neighbouring claim, was staked by John Hanly on the same day. Later in the same year the Anaconda was staked by W. A. Puckett, and the Big and Little Chief by Wm. McTaggart and Andrew Oleson. In the following year the district was pretty thoroughly prospected on the surface, and most of the important claims, including the Pueblo, Best Chance, Arctic Chief, Grafter, Valerie, War Eagle, and numerous others, were discovered and staked.

In 1899, trails were constructed to several of the claims from Whitehorse, and development work was commenced on the Copper King, Anaconda, and Pueblo. Among the noteworthy events of that year was the bonding of the Pueblo, and a group of adjoining claims, to the British America Corporation. The bond was thrown up in 1901, after the completion of 235 feet of sinking and drifting, through what has since proved to be a lean, if not the leanest portion of the lode. No further mining was attempted on this claim until 1906.

6361—1

The early development on the Copper King was carried out by McIntyre and Granger, the owners, and consisted in sinking on various surface croppings. In 1900 a small shipment of ore, the first from the district, was made from this claim. The shipment was made up of nine tons of rich bornite ore, and is stated to have yielded 46·40 per cent of copper. A second shipment of 460 tons of high grade ore was made in 1903.

Other claims on which serious attempts at development were made in the early days of the camp are the Arctic Chief, Anaconda, Valerie, and Grafter. Work on the large magnetite ore body of the Arctic Chief was commenced in 1902, and has been prosecuted at intervals ever since. A shipment of 170 tons of selected ore was made in 1904. A small shipment was also made from the Valerie in 1903, the only ore so far from the southern portion of the camp. The early Grafter workings consisted of about 200 feet of sinking and drifting, and those on the Anaconda of about 300 feet of drifting.

Very little progress was made during the year 1904-5, and the work done was practically limited to that required to hold the various claims. The rising price of copper in 1906 revived interest in the camp, and a number of the most promising claims were sold or bonded to individuals or companies. During the past season active development work was in progress on the Pueblo, Grafter, Arctic Chief, Best Chance, Copper King, War Eagle, and Valerie, and small amounts of exploratory work were done on a number of other claims extending all along the belt.

The total amount of development work so far done in the district, including that of the past season, does not exceed 3,500 feet, and the total shipments to various coast smelters aggregate about 4,000 tons. This slow progress in a camp containing so many favourable showings is remarkable, and is attributed mainly to delay in providing proper transportation facilities. Most of the important mines are situated at distances of from four to seven miles from the present terminus of the White Pass railway at Whitehorse, and are connected with it by wagon roads constructed by the territorial government. The transportation charges to Whitehorse by wagon amount to from \$3 to \$4 per ton, and from Whitehorse by rail and steamer to the various coast smelters to \$6 per ton. The large iron ore bodies on which the camp principally depends, are all comparatively low grade, averaging about four per cent in copper, and the margin of profit on the ores under present conditions is small.

A spur from the main line of the White Pass railway has now been located along a portion of the copper belt, connecting closely with the principal mines, and cheaper transportation in the immediate future is assured. A large tonnage, probably half a million tons, is in sight at the various mines, as a result of recent development work, and extensive shipments are contemplated when the spur is completed.

## SITUATION AND COMMUNICATION.

The Whitehorse copper belt is situated in the southern part of the Yukon Territory, about forty-five miles north of the British Columbia boundary, and extends along the valley of the Lewes river —the principal feeder of the Yukon—for a distance of about twelve miles. The town of Whitehorse, the distributing point of the district, is distant 110 miles from Skagway, at the head of Lynn canal, one of the numerous west coast fiords. Easy communication with the coast is afforded by a well built narrow gauge railway, constructed across the Coast range to Lake Bennett in 1898-9 to facilitate transportation to the Klondike. In 1899-1900 the road was extended down Lake Bennett to Carcross, where it leaves the present waterway, and follows a wide parallel valley, now occupied for some distance by the Watson river, to Dugdale. Here it rejoins the Lewes valley, and continues down it to the present terminus at Whitehorse, a mile below the Whitehorse rapids.

Whitehorse, in addition to being the terminus of the railway from the coast, is also the head of navigation on the Yukon. In the summer season, lasting about five months, steamers sail regularly for Dawson, a distance of 450 miles, connecting there with larger steamers, which descend to the sea, a further distance of 1,572 miles. In the winter season communication is kept up by means of stages.

## TOPOGRAPHY.

The main feature in the topography of the district is the great valley of the Lewes river. Opposite Whitehorse the valley has a width, from base to base of the enclosing hills, of fully four miles. It is bordered on the east by Canyon mountain, a long symmetrical limestone ridge, rising to a height of 2,500 feet above the valley bottom, and 4,730 feet above the sea. The western boundary is more broken, and consists, from south to north, of the Golden Horn, a prominent peak 5,400 feet in height: a wide irregular ridge culminating in Mount McIntyre,[1] 5,200 feet, and Mount Haeckel, 5,318 feet in height. These elevations are separated by wide drift-filled depressions, extending across the range.

The central portion of the old pre-glacial valley is floored with silts and boulder clays, and through these the Lewes has cut the narrow, winding secondary valley, about 200 feet in depth, in which it now flows.

The surface of the old valley rises gradually from the edges of the secondary valley to an elevation of about 600 feet at the bases of the enclosing ridges. It is rough and exceedingly varied in character. Small plains underlaid by silt alternate with rolling boulder clay hills and ridges, and these in turn are replaced at many points by areas of low, hummocky, granite hills; and near Hoodoo creek by small cliff bordered basalt plateaus. Short terraces occur frequently, but do not form continuous conspicuous lines along the valley.

A feature of the old valley bottom is, the number of small canyon-like valleys, from fifty to a hundred feet or more in depth, which incise its rocky floor in all directions. Some of these carry the present drainage from the hills, while others are waterless, or enclose small drainless lakes, and were evidently carved out by temporary Pleistocene streams.

The streams of the district, with the exception of the Lewes river, are all small. The most important are Wolf, Hoodoo, McIntyre, and Porter creeks. The derangement of the drainage system during the glacial period, and the partial deflexion of the streams from their old courses, is illustrated by the varied character of their valleys. These are sunk through drift, and are wide and irregular where the pre-glacial channels are followed, and after leaving them become narrow rocky gorges.

The Lewes river, like the smaller streams, failed in places to regain its old channel after the disappearance of the ice. Above Whitehorse it swings to the west, away from its old course, and has

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1 Named after Jack McIntyre, the first claim holder in the district. It has been called Mt. Granger, but this name is used by Mr. Cairnes to designate a mountain near Coal lake, only a few miles away.

sunk a new channel, several miles in length, through the basalt sheet which here underlies the drift. Miles canyon, and the Whitehorse rapids, with the intervening stretch of rapid water, are the results of this deviation. Above, and below these obstructions to its navigation, the Lewes widens out, and flows tranquilly along a valley excavated entirely in drift.

## FOREST.

The wide bottom lands of the Lewes valley, in the vicinity of Whitehorse, and the lower slopes of the bordering ridges, are clothed everywhere, except on a few dry hillsides and where fires have passed, with an almost continuous and moderately dense forest growth. Ascending the slopes the trees become dwarfed and scattered, at an elevation of 1,700 feet above the river, or 3,800 feet above the sea, and 500 feet higher up cease completely. The upper slopes of the higher peaks and ridges are bare.

The most important tree in the district is the white spruce—(*Picea alba*). It grows at all elevations, up to the timber line. The best groves are usually found in flats along the various streams, and in depressions in the lower slopes of the ridges. In favourable positions this tree attains a size of from 12″ to 24″, and occasional examples exceeding 30″ in diameter near the base were noticed. It furnishes a strong, easily worked timber, well adapted for the usual mining needs. The black spruce (*Picea nigra*) is common; but never grows to a workable size. The black pine (*Pinus Murrayana*) occurs in extensive forests on the sandy benches bordering the river. The trees of this species are never large, seldom exceeding 12″ in diameter, and the timber is weaker and less durable than that obtained from the white spruce. The birch (*Betula papyrifera*) is only occasionally seen, and never attains a large size. The fir (*Abies subalpina*) is abundant near the timber line, and on the mountain slopes immediately beneath it. The aspen (*Populus tremuloides*), and the balsam poplar (*Populus balsamifera*), are both common.

The shrubs are represented principally by the alder, various species of willow, some of which grow to a considerable size, and the dwarf birch (*Betula glandulosa*).

Timber for mining purposes is plentiful at present, notwithstanding the numerous destructive fires which have ravaged the district, and the supply in the immediate vicinity of most of the principal claims is ample for some years to come. When this becomes exhausted, the needs of the camp can easily be supplied from the forested valleys of the upper Lewes and its tributaries.

## WATERPOWER.

The Lewes river, four miles above Whitehorse, contracts and flows rapidly through Miles canyon. The canyon has a length of 3,000 feet. Below it the river widens out, but continues swift down to the Whitehorse rapids, distant 2·75 miles from the head of the canyon. The fall of the river in the canyon is 16·2 feet, in the Whitehorse rapids 9·5 feet, and in the whole stretch of rapid water, 49 feet. Additional fall, if necessary, can easily be obtained by damming the river at the head of the canyon. Its width here is about 90 feet, and it is enclosed between nearly vertical basalt walls.

The Lewes river, according to measurements made by Mr. A. J. Beaudette, territorial mining engineer, has a flow at this point of about 135,000 miner's inches at ordinary stages of the water, and with even a moderate head, is capable of furnishing a large horsepower.

A second possible source of water is from Fish lake, a sheet of water six or seven miles in length, situated in a high valley west of Mount McIntyre, at an elevation of about 1,456 feet above Whitehorse. Fish lake discharges at present into the Takhini river. The pre-glacial outlet probably followed the depression between Mount McIntyre and Mount Haeckel, leading into the Lewes valley; now drained by a branch of Porter creek. The elevation of this pass, measured roughly with the aneroid, is less than that of the lake. The outlet of Fish lake has a steep declination, and in the early summer months is a large, swift stream. Later on, the flow decreases rapidly, and at the end of September does not exceed 1,500 miner's inches. A large constant supply from this source can only be obtained by impounding the spring floods in the lake.

The streams crossing the Lewes valley from the bordering mountain ranges, with the possible exception of Wolf creek, are all too small to be used for power purposes.

## MINING CONDITIONS.

The Whitehorse ores at present are shipped for treatment to the various coast smelters. Transportation charges from the mines to the smelters, by wagon, rail, and steamer, amount to from $8 to $10 a ton. These charges, as stated in a previous page, will be materially reduced when the branch line along the belt from the White Pass railway is completed. The ruling smelter charges for the siliceous ores are $1.50 per ton, with a deduction of 1·3 per cent of copper for loss. The iron ores, with a high excess of iron, receive more favourable treatment.

Wages in the district are not much higher than in British Columbia. Hand miners receive from $3.50 to $4 per day with board for eight hours' work, labourers $3.50 for ten hours, carpenters and blacksmiths $4 to $5, and engineers $5 to $6 per day. Supplies of all kinds are expensive, owing to the high inward freight rates of from $50 to $60 and upwards, per ton.

Mining expenses are variable, and depend upon the character of the ore body and accessibility to Whitehorse. With the exception of pumps and steam hoists, no machinery has so far been installed. The altered garnetized rock usually encountered is hard, but breaks readily. Drifting with hand drills usually costs about $15 per foot, and sinking from $30 to $40 per foot. The total cost of ore extraction in the large iron masses is not expected to exceed $1 per ton.

## CLIMATE.

The climate at Whitehorse, notwithstanding the high latitude of 60° 45′ N., is not unfavourable for mining operations. The summer weather is dry, seldom excessively hot, and is hardly surpassed anywhere. The winter season, lasting from November to April, is cold, sometimes extremely so, the thermometer occasionally dropping to 60° or more below zero. These cold spells are, however, exceptional, never last long, and do not seriously interfere with outside work. The ordinary winter temperatures of from zero to 40° below, are not unpleasant, and entail no hardships when properly prepared for.

## ROCKS.

### GENERAL STATEMENT.

The old schistose formations, prominent in other parts of the Yukon Territory, are not represented in the Whitehorse district, and the oldest rocks known consist of limestones, referred to the Carboniferous.

The limestones have been broken through and largely destroyed by three distinct igneous invasions; only fragments of the original formation now remain. The earliest invasion was by porphyrites of various kinds. These were intruded, partly at least, along the bedding planes of the limestone, and form sheets, or sills, up to 1,000 feet, or more, in thickness.

The second invasion is represented by plutonic rocks, extraordinarily varied in their mineralogical composition. Normally they are hornblende granites; but transitions to diorites, hornblende, and augite syenites, and even to gabbros, are frequent. These rocks cover a large portion of the district. They may represent an outlier of the Coast range granitic batholith.

The third period of igneous activity resulted in the production of the numerous porphyrite dikes now found cutting indiscriminately across limestones, granites, and older porphyrites. The dikes occur throughout the district, but are especially large and numerous in the central portion. In certain areas here they cover approximately half the surface.

The youngest rocks in the region are basalts. These originated outside the district reported on, and entered it through the depression north of the Golden Horn. They flowed down the valley of Hoodoo creek to the Lewes river, and continued down the valley of the latter stream to the Whitehorse rapids and up it to Wolf creek. Isolated areas at several points show that a considerable portion of the original basalt sheet has been destroyed.

The basalts were followed by the deposits of the glacial age, consisting mostly of boulder clays and silts.

The sequence and probable ages of the various formations are as follows:—

Pleistocene—Silts, boulder clays.
Tertiary—Basalts.
Mesozoic—Porphyrite dikes, granites, porphyrites.
Carboniferous—Limestone.

## THE LIMESTONES.

Limestones, probably of Carboniferous age, although no direct proof of this was obtained, are the basement rocks of the district. Their distribution along the mineral belt is somewhat irregular, as they have been repeatedly intruded by igneous rocks, and the original formation has been broken up into a number of isolated areas, ranging in size from small inclusions a few feet across, to large uneven masses, several miles in length, and a mile or more in width. The outlines of the larger areas, where not concealed by drift, are shown on the accompanying map.

The general character of the limestones along the mineral belt is very uniform. No associated argillaceous or dolomitic bands were observed. In the interior of the larger areas they appear as heavily bedded, moderately crystalline, dark greyish rocks, blotched in places with small white calcite markings resembling fossils. The principal impurities consist of small siliceous usually cherty aggregates.

These are not common, and are often entirely absent. The dark coloration in the specimens examined proved to be due to the presence of numerous small specks of organic matter.

The beds occur at all attitudes, from horizontal to vertical; but the tilting as a rule is moderate and regular. Sharp flexures and dips of over 45° are exceptional.

Approaching the granite areas the character of the limestone undergoes a gradual change: it becomes more coarsely crystalline, the dark coloration disappears, or lightens, and the beds are frequently welded together in solid masses. Secondary minerals make their appearance, and often develop in sufficient quantities to obscure the original rock, and in limited areas to replace it altogether.

The metamorphism of the limestones in the vicinity of the granites, while always apparent, varies greatly in intensity. Along the greater portion of the contacts it is represented merely by lighter colours and a coarser crystallization, with little or no mineralization. At irregular intervals the affected zone widens, and the limestones, in addition to being coarsely recrystallized, are more or less heavily charged with a great variety of contact metamorphic minerals. A list of these is given in another part of the report.

The porphyrite intrusions have not affected the limestones in the same manner as the granites. A coarser crystallization is often noticeable approaching the larger masses; but in no case is this accompanied by any large development of secondary minerals.

## PORPHYRITES.

### *Distribution.*

Greyish porphyrites, with the exception of the granites, are the most widely distributed rocks in the district. They outcrop over large areas in the region extending from Mount Haeckel to Mount McIntyre, and extend southward along the base of the latter in long bands and disconnected areas to Hoodoo creek. They also occur on the summit of the Golden Horn, on Wolf creek, and along the Dawson road north of the Anaconda claim. They are intimately associated with the limestones, and are often clearly interbanded with them. The smaller areas are usually enclosed in limestone, and in some instances irregular patches of limestone are included in the porphyrites.

### *General Character.*

The porphyrites invaded the limestones mostly in thick sheets, parallel, or nearly so, to the bedding. The sheets are seldom horizontal, the dips usually ranging from 10° to 45°.

Since their intrusion the covering limestones have been partially removed by erosion, and the porphyrites now form the surface rocks over large areas. The small rounded areas common in the limestone may in some instances represent stocks, but this point could not be definitely determined, as good contact exposures are infrequent. It is probable that the majority of them are small laccolitic masses, deeply eroded. The mineralogical composition of the rocks in the small and large areas is practically the same, and both are usually banded parallel to the bedding of the limestone.

While the porphyrite sheets and the limestones are characteristically conformable, unconformable contacts, due to the breaking of the intrusive across the limestone, also occur. Angular fragments of limestone, often of considerable size, are frequently found enclosed in porphyrite. The inclusions are often isolated, but in some instances are grouped closely together, and a limestone breccia, with porphyrite as the cementing material, is formed. This rock in extreme cases is practically a shattered limestone cemented by porphyrite.

The porphyrites are generally greyish in colour, and moderately fine grained in texture. They are nowhere coarse, and near the limestone contacts often pass into fine grained compact rocks, easily mistaken in hand specimens for quartzites. They have usually a banded appearance due to slight differences in coloration and texture. The direction of the banding follows closely the bedding of the limestones.

North of the Dalton trail, in the lumpy ridge overlooking Fish lake, the character of the porphyrites is somewhat different. They are filled with rounded and subangular boulders, mostly of granite, and less commonly of slate and a basic eruptive. The boulders are of all sizes up to eighteen inches in diameter, and are numerous enough in places to give the rock a decided conglomeratic appearance. The matrix is, however, an intrusive porphyrite somewhat finer grained than usual, and the boulders probably represent fragments torn from the formations which it invaded.

In the southern part of the district, the large porphyrite area, shown on the map as crossing Wolf creek, and extending southward, may be partly tufaceous in origin. It was not closely examined, and the rocks may be younger than those in the northern areas.

The porphyrites are massive in structure and are seldom much altered. They are often traversed by numerous joints, the strongest set usually developing at right angles, or nearly so, to the dip of the sheet. Their age is only known relatively to the other formations in the district. They intrude the limestones, and are themselves cut at a number of points by the granites.

### *Petrography.*

In hand specimens the porphyrites have the appearance of fine, to medium grained, granular rocks, without conspicuous porphyritic structure. They differ in this respect from the later porphyrite dikes, which are nearly always profusely sprinkled with large white feldspar crystals. In thin sections they usually show a crypto-crystalline, or microcrystalline groundmass, made up largely of plagioclase, with some orthoclase and quartz; and varying quantities of hornblende, augite, biotite and magnetite, through which larger, well formed crystals of plagioclase, rarely quartz and orthoclase, and the various iron-magnesian minerals, are porphyritically distributed. In some sections the grain is fairly uniform, and none of the constituent minerals are of large size.

In the sections examined, hornblende porphyrites, in which hornblende is the principal, and often the only iron-magnesia mineral present, is much the most abundant variety represented. Augite, and biotite porphyrites both occur, but are less common.

Quartz is often present in the ground mass of the porphyrites, and, in exceptional cases, large crystals are also developed. A whitish, fine-grained rock, obtained from the porphyrite area west of the Arctic Chief, contained large, well defined phenocrysts of quartz, orthoclase, and plagioclase, set in a microcrystalline base, made up of biotite, some magnetite, quartz, and feldspar.

The porphyrites are seldom fresh. The feldspars are always more or less clouded, and the iron-magnesian minerals are often replaced entirely by chlorite, and epidote. Unlike the limestones, they have suffered little from the granite intrusion. Occasional grains of chalcopyrite, hematite, magnetite, and other secondary minerals, are found in a few places along the contact, but nowhere in quantity, and the areas affected are never large.

### GRANITIC ROCKS.

#### *Distribution.*

Granitic rocks underlie the greater part of the district reported on. They outcrop in numerous exposures along the western side of the Lewes valley, and although only seen at a couple of points, probably extend continuously eastward under the drift and basalts to the base of the limestone ridge of Canyon mountain, which borders the valley on the east. Mount McIntyre, west of the Lewes valley, is built entirely of granitic rocks, and they also occur in association with porphyrites on Mount Haeckel, and the lower part of the Golden Horn.

The granitic stock, or batholith, extends in all directions; except eastward, beyond the limit of the district mapped, and its full areal distribution is not known. Its outline, especially when it adjoins limestone, is exceedingly irregular and jagged. The exposed contacts are marked nearly everywhere by a succession of bays, and sharp promontories. Inclusions of limestone fragments in the granitic area are of frequent occurrence.

#### *General Character.*

The prevailing colour of the granite, and associated granitic rocks, in the valley of the Lewes is a light grey. With increasing basicity the colour changes to a uniform dark grey, or grey mottled with small rounded basic segregations. West of the Lewes valley, on Mount McIntyre, and on the east slope of the Golden Horn, the colour is light reddish. The Mount McIntyre granitic rocks are separated from those in the valley by a band of limestones and porphyrites, and the difference in coloration and general appearance led at first to the belief that they represented a later intrusion. Going southward the two granitic areas meet at the foot of the Golden Horn. Here the occasional exposures projecting through the drift appear to show a gradual gradation from the coloured to the grey variety, and no field evidence of two intrusions was obtained.

The texture of the granitic rocks varies from medium, to moderately coarse, and is very uniform throughout the district; except on the east slope of the Golden Horn. At this point they pass in places into coarsely porphyritic variety.

The structure is everywhere massive. In thin sections some crushing is occasionally observed, but is exceptional, and has nowhere proceeded far enough to produce shear planes. Sharp jointage partings are numerous, and often cut the rock into angular blocks. The joints dip at all angles, and their direction varies with the locality.

The granitic rocks show great diversity in the amount of weathering they have undergone. While they are usually hard and compact at the surface, in a few areas they are badly decomposed to a depth of fifty feet or more. North of the Copper King, crumbling granitic rocks, soft enough to be crushed between the fingers, outcrop in the banks of McIntyre creek, and extend northward across Porter creek for half a mile. Similar smaller areas occur on the Grafter road, and at other points. In hand specimens, the decomposed granitic rocks show no quartz, and consist mostly of feldspar, and chloritized ferro-magnesia minerals. They pass gradually into the common hard quartz-bearing variety.

In thin sections, the granites near the surface, like the porphyrites, are seldom fresh. The feldspars are nearly always more or less turbid, and are often unrecognizable; while the dark constituents are frequently entirely replaced by chlorite, epidote, zoisite, and other decomposition products.

### *Petrography.*

The mineralogical composition of the granitic rocks is exceedingly diverse in different parts of the district, and a number of types are represented. Ordinarily they are medium-grained hornblende granites, consisting essentially of quartz in grains of various sizes, hornblende, and orthoclase. The quartz as a rule is markedly free from inclusions. Plagioclase in some quantity, usually andesine, or oligoclase, where determinable, is nearly always present; while augite, and biotite, especially the former, are both common. The less important accessory minerals are magnetite, ilmenite, sphene, and apatite. A micro-pegmatitic intergrowth of orthoclase and quartz, was observed in a few specimens, but is not common.

The normal hornblende granites pass gradually in many places into quartz-diorites and diorites. In these rocks the predominating feldspar is a plagioclase, ranging in the specimens examined from an oligoclase to an acid labradorite. Orthoclase and quartz, in some quantity, are seldom entirely absent. The principal iron-magnesia mineral is hornblende. Augite is common as an accessory, and biotite occurs in most of the sections. Other accessory minerals are magnetite, ilmenite, and sphene. In some instances the augite exceeds the hornblende in amount, and gabbro-diorites are formed. The latter, in a few places, pass into a gabbroic rock, made up almost entirely of augite, and a plagioclase feldspar.

A syenitic phase of the granitic rocks is not uncommon. In this, the quartz and plagioclase disappear, or occur only as accessories; and hornblende and orthoclase, and more rarely augite and orthoclase, are the principal constituents.

The areal distribution of the numerous varieties of the granitic rocks is exceedingly irregular, and no attempt was made to outline them. They are all considered to be modifications of a single intrusive body.

The granites along the limestone contacts are often impregnated for varying distances up to 400 feet, with the same contact metamorphic minerals which occur in the limestone. The mineralization is irregular, and occurs only at points where the limestones are also greatly altered, and mineralized. The principal occurrences are described in connexion with the ore bodies.

### DIKES.

The dikes of the district consist of a few small aplite veins cutting the granites, occasional apophyses from the granite, and more rarely from the porphyrites, and an extensive system of porphyrite dikes.

The latter are so large and numerous in certain portions of the district that, they are entitled to rank as a formation. They occur mostly along the western side of the valley of the Lewes, and in the lower slopes of the ridge bordering it on the west. They are comparatively rare in the north part of the district, and increase in numbers going south along the belt, to a maximum in the neighbourhood of Hoodoo creek, where they occur in such abundance as to constitute, in places, the principal rock. South from Hoodoo creek, they continue fairly numerous to the southeastern end of the district examined.

They strike in various directions, although the general trend is across the valley, following an approximate east-west course, and are usually large, well defined bodies, ranging in width from a few feet to over fifty feet, and occasionally traceable for half a mile or more.

The porphyritic dikes followed the granites in order of intrusion, and are found cutting all the older formations. They are also later than the mineralization of the granites and limestones; but probably, judging from their condition, not much later. They are the youngest intrusive in the district, and were followed after a long interval by the basalts.

In hand specimens the dike rocks are usually light to dark grey in colour. The texture of the smaller dikes is usually fine grained, and somewhat uniform; while the larger ones, with few exceptions, are spotted with white, medium sized, and large feldspar phenocrysts, often arranged in lines with the longer axis parallel to the walls. They are comparatively fresh looking rocks as a rule, but are occasionally epidotized on the surface. In one instance, a development of garnet and epidote was noted in the side of a dike traversing limestone, very similar to that which takes place in the granites where they adjoin limestone.

A number of specimens from different parts of the district were examined by Mr. Haughton, who reports on them as follows:—

'While several varieties are represented, the great majority of the specimens examined are classed as diorite, or gabbro porphyrites.'

These diorite and gabbro dikes, or diorite porphyrites, and gabbro porphyrites, vary in colour from light grey to an almost black shade. They are for the most part very fine grained, the darker coloured varieties having an almost micro-felsitic groundmass. In most cases, however (with the specimens examined), the groundmass was cryptocrystalline, and microcrystalline.

All these dikes have an extremely well defined panidiomorphic or porphyritic structure, the phenocrysts are, in many instances, of very large size, and show up prominently in the hand specimen.

The phenocrysts are of two kinds in each variety: plagioclase, and amphibole, or mica (occasionally both occur), in the diorite porphyrite; and plagioclase and pyroxene in the gabbro porphyrite

The feldspar, in the specimens examined, is almost invariably extremely turbid, and only two specimens were found which were sufficiently clear and fresh to allow the extinction angles to be correctly measured. In No. 16, the feldspar is an andesine, or an acid labradorite, and in No. 20 it is labradorite.

The plagioclase phenocrysts, as a general rule, are larger in size, and of more frequent occurrence than the iron magnesia phenocrysts. The feldspar phenocrysts are usually twinned, and in many cases the smaller sized phenocrysts (the iron magnesia constituents) also show twinning.

In the diorite porphyrite, the iron magnesia constituent is green hornblende, usually occurring in good crystalline form; but often, owing to decomposition, and to strains due to crushing, etc., the original form of the mineral is destroyed. Biotite also occurs in these rocks, sometimes singly, but usually with the hornblende.

In the gabbro porphyrite the iron magnesia mineral is augite. It is often twinned, and appears when fresh to have good crystalline form, the cleavage in most instances being very clear and distinct.

Quartz occurs quite frequently in these rocks, both as a primary and a secondary mineral. In the gabbro and diorite porphyrites, however, it only occurs as a primary mineral in the latter class, and in both as a mineral of secondary origin.

Magnetite occurs very frequently in these rocks, and occasionally hematite, ilmenite, pyrite, and chalcopyrite are also found in them.

The groundmass of these dikes is composed of feldspar, and the iron magnesia minerals, and in every case is very fine grained. The groundmass of the average diorite porphyrite is composed of plagioclase feldspar, with hornblende or mica (sometimes both), while in the gabbro porphyrite the hornblende and mica are replaced by augite. Usually the groundmass is cryptocrystalline, sometimes cryptocrystalline and microcrystalline, and rarely microfelsitic.

Several varieties were examined which appeared to be intermediate between the diorite and gabbro divisions, and have been classified as gabbro-diorite porphyrites. These rocks contain hornblende, mica, and augite as their iron magnesia minerals; but in all other characteristics are similar to the average type.

All the specimens examined, have undergone decomposition to a very marked extent, and a considerable quantity of decomposed or secondary minerals is present. Chlorite, epidote, and calcite are

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Miles Cañon, Lewes River.

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the minerals which occur most frequently, and plentifully in this class, but zoisite, kaolin, and muscovite, also occur.

Syenite porphyry dikes occur at a few points, and are probably mostly apophyses from the granite; although field evidence of this was only obtainable in two instances. They consist of orthoclase, some plagioclase, occasionally a little quartz, and usually more or less augite. Dikes composed almost entirely of orthoclase, with subordinate amounts of plagioclase, and classed as bostonites, were found at two points. Their relationship was not determined.

Miles Cañon, Lewes River.

### BASALTS.

These rocks cover a comparatively small area, and are not important economically. They are traceable from a point on the northern slope of the Golden Horn eastward, down the valley of Hoodoo creek, for a distance of two and one-half miles. At this point the flow turns abruptly northward, and continues down the valley of the Lewes river past Miles canyon to the Whitehorse rapids, a further distance of five miles, where they disappear beneath the drift. Small isolated areas occur on McIntyre and Wolf creeks.

The basaltic sheet has been partially destroyed by erosion, and is now narrow, and of moderate depth. The full thickness is rarely seen, but probably seldom exceeds 150 feet, and is often much less.

The basalts are well exposed along Hoodoo creek, and in the vertical walls of Miles canyon, and Crater lake. They are strongly jointed both vertically and horizontally; and the cliffs in many places have the appearance of being built up of angular blocks, or where the edges of these are weathered, of rounded boulders. The characteristic columnar structure is only occasionally exhibited.

The basalt is seldom vesicular, and usually occurs as a compact, greyish, occasionally dark greyish, and reddish rock, in which augite is the only mineral that can be distinguished. In thin sections, it shows a fine grained groundmass, made up of augite, plagioclase, and magnetite, through which larger grains of augite, often stained red with iron oxide, are porphyritically distributed. No olivine was observed in the specimens examined.

It is a comparatively young rock, and was extruded after the region had assumed its present general topographic form.

GLACIAL DEPOSITS.

The district reported on is situated within the limits of the Great Northern glacier, and during the glacial period was totally submerged by ice. Small erratics, chiefly well worn granitic and slate pebbles, occur sparingly on the upper slopes and summits of Mounts Haeckel, McIntyre, and the Golden Horn—the highest peaks in the district examined. The latter has an elevation of 5,480 feet above the level of the sea, and of 2,080 feet above the lowest part of the Lewes River valley opposite it. The difference between the two, 3,400 feet, represents the minimum thickness of the ice in the valley.

Ice groovings and striæ, the principal indices to the direction of ancient ice movement, are rare, but have been preserved at a few points. In all cases observed they point directly down the valley, which here runs almost due north.

The deposits of the ice age consist mainly of boulder clays and silts. Boulder clays of the usual character occur both in the valley bottom and high up on the bordering ridges. Exposures were found on the slopes of Mount Haeckel within 500 feet of the summit, at an elevation of 2,750 feet above the valley. In the mountain region the old pre-glacial depressions between the ridges and the wide valley of the streams draining them have been largely levelled up, with heavy accumulations of boulder clay. Small sloping plains, with smooth or rolling surfaces formed in this manner, border the mountain portions of McIntyre, Hoodoo and other creeks, and extend up their branches for varying distances.

In the wide bottom of the Lewes valley the boulder clay is very unevenly distributed. It occurs in terraced benches bordering the lower slopes of the ridges, in groups of conical hills, or long uneven ridges, filling old valley depressions and spread over the surface in fairly uniform sheets. In the neighbourhood of Ear lake it is heaped up into intricately interlacing ridges, enclosing deep steep-sided basins, often partially filled with water. Ear lake occupies one of these drainless depressions.

While the greater portion of the valley bottom is more or less completely buried beneath a mantle of drift, from a few inches to over 200 feet in thickness, a few areas, mostly situated along the western part of the granite belt and in the basalt region near Hoodoo creek, are practically bare, and rough rock surfaces are exposed.

The absence of drift in most of these areas is probably attributable to its being swept away by streams issuing from the melting glacier. The low, rough granite hills east of McIntyre creek, were probably never deeply buried.

The silts are less widely distributed than the boulder clays, and are confined to the central portion of the old valley. The present secondary valley of Lewes river, for some distance below Whitehorse rapid, is sunk almost entirely through them. Good sections 195 feet in height are exposed in the valley banks west of Whitehorse. This is a minimum thickness, as the lower portion of the deposit is concealed.

The silts are very light coloured, in places almost pure white, and were exposed from conspicuous banks. They are stratified, as a rule, the beds varying from one to three inches in thickness; and in most sections seen are very homogeneous throughout; although they occasionally enclose scattered pebbles and thin pebble beds. West of Whitehorse, they pass upwards into gravel and sand.

The silts are intimately connected with the boulder clays, and in a general way are contemporaneous with them. They represent accumulations of the fine material brought down by glacial streams, and deposited when the current slackened sufficiently, or still water was reached. They were not laid down—as has been supposed—in one large continuous sheet of water; but in separate basins, some insignificant in size, and at different elevations. In some instances the basins in which they accumulated were subsequently over-ridden by the advancing glacier, and boulder clays were deposited over them.

Silts indistinguishable in appearance and general character from those outcropping along the Lewes valley, are being laid down at the present time in the upper portion of Kluane lake, and the lower sluggish portion of Slims river, its principal feeder. The silt-laden waters of this stream are derived from the Kaskawulsh glacier, a surviving fragment of the great glacier, and the conditions existing along it are illustrative of those which must have obtained on many of the streams issuing from the latter.

## ECONOMIC GEOLOGY.

### GENERAL CHARACTERISTICS OF ORE DEPOSITS.

#### *Distribution.*

The copper belt, as determined by present discoveries, extends along the valley of the Lewes river, from a point east of Dugdale, on the White Pass railway, northwestward to the base of Mount Haeckel, a distance of about twelve miles. The width of the belt seldom exceeds a mile, and in places is confined to a single line. The distribution of the discoveries along the belt is exceedingly irregular. The croppings follow a series of limestone areas enclosed in granite, or lying between granite and porphyrite. Where the limestone is absent the belt is practically barren; and considerable stretches of it otherwise favourable, such as that extending from the Spring Creek to the Pueblo claim, a distance of three and a half miles, are hopelessly buried beneath heavy accumulations of drift.

#### *Ore Bearing Formations.*

The rock formations of the district consist, in order of age, of limestone, porphyrites, granites and grano-diorites, an extensive system of porphyrite dikes, and finally, basalts. Of these only the limestones and granitic intrusives are important economically. The principal ore bodies now being developed, occur in the limestone, close to or adjoining the granite. Numerous discoveries have also been made in the granite, often at considerable distances from the limestone. The limited work done on these has not so far disclosed ore bodies of commercial value. The constituent minerals, and general character of the ore bodies in the two formations, are very similar.

Copper minerals seldom develop in the porphyrites, but are not altogether unknown. The porphyrites are often closely interbanded with the limestones; and when this occurs in an altered area, both rocks are sometimes affected. The mineralization of the porphyrites is usually limited to a narrow zone, a few inches in width, bordering the limestone.

### *Principal Minerals.*

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. Copper minerals resulting from the oxidation of the sulphides are conspicuous at all the workings; but except at the Pueblo, are seldom important as ores. They include the two copper carbonates, malachite and azurite, the red and black oxides cuprite and malaconite, and the silicate chrysocolla. The cuprite is occasionally associated with small grains of native copper.

The iron sulphides are not abundant and nowhere form large masses. Scattered grains of pyrite occur in the granites, altered limestones, and more frequently in the porphyrites, but are rarely found in connexion with the ore bodies. Small quantities of pyrrhotite occur at the Arctic Chief. It was not observed elsewhere.

The iron oxides, magnetite and hematite, on the other hand, are widely distributed, and both occur in large masses. Magnetite is especially abundant, and is seldom absent from the mineralized areas. Lenses of this mineral, ranging in size from a few inches to 360 feet in length, are found all along the belt, mostly in the altered limestones, but also occasionally in the altered granites. Hematite is less common. It occurs in large tabular crystals at a number of the showings, and is the principal mineral in the great Pueblo lode.

Other metallic minerals of less frequent occurrence are, arsenical pyrites, stibnite, galena, sphalerite, and molybdenite. Gold and silver in some quantity occur in all the ores. The values range from traces up to several dollars per ton. Gold is occasionally found native.

The principal non-metallic minerals accompanying the ores are garnet (andradite), augite, tremolite, actinolite, epidote, calcite, clinochlore, serpentine, and quartz. Of these, garnet, augite, calcite, and tremolite, are the most abundant. Quartz is sparingly distributed, and seldom occurs in quantity.

## ORE BODIES.

The ore bodies fall into two classes: those in which the copper minerals are associated with magnetite and hematite, and those in which various silicates, principally garnet, augite, and tremolite, are the chief gangue minerals.

The magnetite ore bodies are numerous, and occur enclosed completely in altered limestone, along the lime-granite contact, and in a few instances, in areas of altered granite. The largest bodies so far discovered are, the Best Chance, 360 feet in length; the Arctic Chief, 230 feet; and the Little Chief, 100 feet. The magnetite masses are always sprinkled more or less plentifully throughout with grains and small masses of bornite and chalcopyrite. The two sulphides occur, both separately and intergrown, and are of the same age as the enclosing magnetite. The copper percentage varies greatly in different parts of the same lode, the general average approximating four per cent. The gold and silver are negligible in some of the ore bodies, and important in others.

Besides the copper minerals, serpentine, calcite, clinochlore, and other secondary minerals, are often associated with the magnetite, and rarely pyrrhotite and sphalerite.

Hematite masses are much less common than magnetite, only one large body being known. This is the Pueblo lode, on Porter creek. The upper explored portion has developed altogether in limestone. Granite outcrops in the vicinity, but its contact with the limestone is concealed by drift. It differs from the magnetite ore bodies principally in the greater oxidation of the copper minerals. It is more porous, and the original sulphides or sulphide have been largely converted by surface waters into carbonates, oxides, and silicates. Some chalcopyrite survives in portions of the lode. No bornite has been found.

Showings characterized by a garnet-augite-tremolite gangue are numerous wherever the lime-granite contact is exposed. They vary in size from a sprinkling of copper minerals to considerable lenses of shipping ore, such as those developed on the Grafter, Copper King, War Eagle, and Valerie. All the important ore bodies of this class, so far discovered, occur in the limestone, close to the granite, and are often separated from the granite by a zone of more or less completely replaced limestone. The valuable minerals are similar to those in the iron masses, and consist mostly of bornite and chalcopyrite, carrying small quantities of gold and silver. At the Valerie, bornite is absent, and the chalcopyrite is associated with mispickel, the only known occurrence of this mineral in the camp.

The ore bodies of this class are occasionally tabular in shape, and have the appearance of following particular limestone beds; but in most cases the outlines are very irregular. The Copper King and

Valerie lodes are short and blunt, while that on the Grafter, as shown in the present workings, is shaped like a horseshoe, and partially encircles a core of unreplaced limestone. The copper minerals at the Grafter and Copper King stop rather abruptly against a marble foot-wall; but as a rule they have no definite limit, and extend in diminishing quantities for some distance beyond the valuable portions of the lode. In some instances, as on the Anaconda, the ore alternates with bands of limestone, and limestone replaced by garnet and augite.

None of the ore bodies have so far been followed to a greater depth than 100 feet, and the question of their downward extension has not been decided practically. At the limited depths reached, some of the lodes show increased, and others decreased volumes, while the character of the ore remains unchanged. Contact replacement deposits, the class to which these belong, are apt to be bunchy, and somewhat uncertain; but theoretically, may descend as long as the limestone lasts. They are dependent on the limestone, and the deposits formed in the larger areas will probably prove more permanent than those in the small inclusions. The latter are themselves liable to be cut off a short distance below the surface.

The copper percentage in the siliceous ores is higher as a rule than in the iron ores: those shipped up to the present time probably averaging over eight per cent. The precious metal contents are moderate, seldom exceeding $3 per ton.

The following analyses of the Arctic Chief magnetite ore, and of siliceous ores from the Grafter, War Eagle, and Valerie, are furnished by Mr. Robert Smart, territorial assayer, Whitehorse, Yukon Territory:—

| | Arctic Chief. | War Eagle. | Grafter. | Valerie. |
|---|---|---|---|---|
| Gold, oz. per ton.......... | 0·21 | 0·05 | 0·05 | 0·075 |
| Silver, oz. per ton......... | 1·20 | 3·30 | 1·55 | 1·05 |
| Copper, percentage ........ | 3·21 | 8·80 | 7·90 | 12·90 |
| Iron, " ........ | 45·50 | 4·40 | 7·12 | 6·39 |
| Alumina, " ........ | 12·08 | .... | 3·88 | 1·95 |
| Lime, " ........ | 0·20 | 23·50 | 21·84 | 14·36 |
| Magnesia, " ........ | 6·71 | 3·00 | .... | 5·65 |
| Silica, " ........ | 9·67 | 55·80 | 56·01 | 23·91 |
| Sulphur, " ........ | 2·53 | 6·60 | 2·78 | 4·21 |

### *Oxidation.*

The iron ore bodies come to the surface practically unaltered, the gossan capping having disappeared during the glacial period. The copper minerals in the dense magnetite masses are slightly oxidized on exposed surfaces along the sides down to the lowest depth reached, and following occasional partings, but the percentage affected is small. The hematite masses, as represented by the Pueblo lode, have suffered more. While the iron shows little change, the copper sulphides, down to a depth of 100 feet at least, are largely replaced by carbonates and other derivative minerals.

The oxidation of the siliceous ores varies with the gangue, but is nowhere extensive. It is greatest where the sulphides, as rarely happens, are enclosed in limestone, and decreases as the proportion of limestone lessens. Where the gangue is composed of a compact mass of secondary minerals, little alteration is noticeable, except on the immediate surface.

### *Classification.*

The Whitehorse copper ores possess all the characters distinguishing ordinary contact metamorphic deposits, and are referred with little hesitation to that class. They occur mostly in metamorphic limestone, close to or in direct contact with the granite or grano-diorite which altered it. Veins, with the exception of occasional thin seams, evidently of secondary origin, are unknown. The ore bodies are irregular in outline, are occasionally banded, and vary in size from small lenticles a fe[illegible]s across—often completely enclosed in limestone—to masses [illegible]ng hundreds of feet in length. The constituent minerals a[illegible]se which everywhere characterize contact deposits. The common ore minerals are magnetite, hematite, bornite, and chalcopyrite, and those less frequently found: tetrahedrite, chalcocite, molybdenite, mispickel, galena, stibnite, pyrrhotite, pyrite, zinc blende, and rarely free gold. The gangue minerals include garnet, augite, tremolite, actinolite, epidote, scapolite, quartz, and calcite. The minerals, both metallic and non-metallic, were deposited metasomatically in the limestone and granite and, with trifling exceptions, are products of [illegible]eriod of mineralization.

There is one important point, however, in which the deposits in question differ somewhat from the published descriptions of other members of this class, viz., in the intense and widespread mineralization of the intrusive itself. While the large aggregates of metallic minerals occur in the limestone or along the contact, numerous small bodies and scattered grains are frequently found wholly enclosed in granite, often at a considerable distance from the limestone. Instances of this occur at Pueblo No. 5, Whitehorse, Keewenaw, and other claims. At the Best Chance large grains of chalcopyrite occur in granite, which microscopically show little alteration.

The development of non-metallic minerals in the granite is probably greater than in the limestone, and the areas affected are wider and more extensive. At the Arctic Chief the granitic rocks are well mineralized for a distance of 400 feet back from the lime contact.

The minerals found in the granite are similar to those in the limestone, although the proportions are somewhat different. The most important are the brown lime-iron garnet andradite, augite, and green epidote. At a number of points both rocks are wholly replaced where they meet, and the original contact usually sharply defined is completely obscured. It is represented by a compact mass of secondary minerals, which fade into granite on the one side, and limestone on the other. The transition from wholly altered to unaltered rock is usually more abrupt in the limestone than in the granite.

The origin of contact deposits, such as those described, has recently been pretty thoroughly discussed by Lindgren, Vogt, Weed, Kemp, and others, and the general conclusion reached, that they are directly due to the passage of gaseous or liquid emanations, laden with the requisite materials from a cooling, but still liquid intrusive magma into the bordering sedimentary, is now generally accepted. In most cases described the migration of material was lateral, and the ore deposits formed in the sedimentary before the adjoining magma solidified. The extensive and simultaneous mineralization of both the intruding and intruded rocks in the Whitehorse district can hardly be explained, except by assuming that the movement was upward, and took place after the former hardened to some depth. The conditions indicate that both the porous limestone and the jointed granite furnished channels for the ascending solutions.

The behaviour of the aplitic dikes is also significant in this connexion. They are not abundant, but the few examples seen in the mineralized areas all show more or less alteration. Granite dikes, apophyses from the main granite area, traverse both the Little

Chief and Pueblo iron lodes. In both instances the dike material is now largely replaced; in the former by magnetite, and in the latter by hematite. The later porphyrite dikes occasionally found cutting the ore bodies have not been affected.

ORE AND GANGUE MINERALS.

*Gold.*

Free gold in visible grains is not common in the district, but occurs occasionally. A small quartz vein encountered in sinking the Grafter shaft was impregnated with it in places, and it has also been found in association with bornite at the Copper King, and with copper ores and lime at the Arctic Chief. All the ores in the camp show traces of gold on assay, and in a few of the mines the gold tenor is important. The Arctic Chief ores average over $4 per ton in gold; the Grafter ores about $2 per ton; and those of the Copper King somewhat less.

*Silver.*

Silver is universally present in the Whitehorse ores. The percentage is usually low, the average tenor ranging from 1 oz. to 3 oz. per ton. A vein of tetrahedrite, rich in silver, was encountered at the 100 foot level of the Arctic Chief mine. It assayed up to 147 oz. per ton.

COPPER MINERALS.

*Bornite.*

This sulphide of copper and iron is the most important mineral in the district. It occurs at all the mines and prospects, with the exception of the Pueblo and Valerie, and at most of them constitutes the principal source of copper. The principal associated minerals are chalcopyrite, magnetite, garnet, tremolite, augite, actinolite, and epidote. In the large magnetite ore bodies, such as the Arctic Chief, Best Chance, and Little Chief, it occurs disseminated in grains and small patches throughout the mass. The distribution is always irregular, certain areas of the magnetite carrying a much higher percentage than others. The richer areas are not confined to any particular part of the lode, but occur both at the centre and near the walls.

Lenses of bornite and chalcopyrite, enclosed in a tremolite-garnet-augite gangue, occur at many places in the district, along the lime-granite contact, notably at the Grafter, Copper King, War Eagle, Anaconda, etc.

*Chalcopyrite.*

This is one of the commonest minerals in the district, and next to bornite the most important copper mineral. It occurs at all the mines and prospects examined, and at the Pueblo and Valerie is the only known copper sulphide present. It occurs in grains and small masses disseminated throughout the iron ore bodies, and is also conspicuous in the altered limestone zones, in association with bornite, garnet, augite, and tremolite. It is often intimately intergrown with bornite, and both minerals were evidently deposited together.

While the greater part, practically the whole, of the chalcopyrite is primary, a small quantity is of secondary origin. This occurs in small veins, seldom more than an inch in thickness, which are found at a few points traversing some of the larger lodes. The associated minerals are bornite, quartz, and calcspar.

*Malachite and Azurite.*

The copper carbonates are conspicuous from their coloration in the oxidized portion of all the lodes, although no large masses have been found. They occur usually as stains, incrustations, or in small globular bunches of radiating crystals. Some small, but beautiful specimens of the latter were obtained on the Spring Creek, and Empress of India claims. At the Pueblo the carbonates are important economically, as they largely replace the primary sulphides in the developed portion of the mine, all of which is in the oxidized zone.

*Cuprite.*

This rich copper ore is common at the Pueblo, where it occurs in short veinlets and small bunches, enclosed in hematite. Cuprite also occurs in small quantities, usually along or near the walls, in the Grafter, Arctic Chief, Valerie, and other mines. It is often associated with native copper.

*Melaconite.*

The black copper oxide is not plentiful, but is occasionally found in small quantities encrusting chalcopyrite. Specimens of chalcopyrite from the Best Chance show the development of the oxide, both on the surface and along cracks which penetrate the sulphide for short distances.

*Chalcocite.*

This mineral occurs in small bunches enclosed in magnetite, at the Best Chance, but is not common in the district.

*Crysocolla.*

Green crysocolla occurs in the Pueblo No. 5 workings, coating a white scapolite. It also occurs in considerable quantities in the silicified portion of the main Pueblo ore body.

*Metallic Copper.*

Native copper occurs sparingly, in grains and small scales, along the walls and in the oxidized portions of many of the lodes. It nowhere forms large masses, and is not of economic importance. It is often associated with cuprite, from which it is evidently derived. It was noted especially at the Grafter, Arctic Chief, and Valerie mines.

ZINC MINERALS.

*Sphalerite.*

Zinc blende is sparingly represented in the district. It was found in small quantities associated with bornite on the Anaconda; and with magnetite, pyrrhotite, and bornite on the Arctic Chief.

ANTIMONY MINERALS.

*Stibnite.*

This mineral was only seen at one point. A small irregular deposit occurs in a whitish crystalline limestone on the Western mineral claim.

LEAD MINERALS.

*Galena.*

Galena was not observed by the writer, but is reported to occur on a claim situated on the limestone belt, extending north from the Valerie.

### MOLYBDENUM MINERALS.

#### *Molybdenite.*

This mineral occurs in scales and small foliated bunches at the Copper King, War Eagle, and other claims.

### ARSENIC MINERALS.

#### *Mispickel.*

Arsenical pyrites occur in considerable quantities at the Valerie, associated with chalcopyrite. It was not observed elsewhere.

### IRON MINERALS.

#### *Pyrite.*

This common mineral is seldom found in connexion with the Whitehorse ore bodies. It occurs in scattered grains in a few places, associated with chalcopyrite, but is never plentiful. The porphyrite rocks are occasionally impregnated over small areas with disseminated grains of pyrite. These weather to a rusty colour, and in a number of places have been staked as mineral claims. They contain no commercial values.

#### *Pyrrhotite.*

The magnetite at the Arctic Chief occasionally encloses small masses of this bronze coloured mineral. It has not been found at the other mines.

#### *Magnetite.*

This is the most abundant and widely distributed metallic mineral in the district. It occurs in grains, aggregated into lenses, and in irregular masses, from a few inches to 360 feet in length. While the large bodies, such as those on the Best Chance, Arctic Chief, and Little Chief claims, have developed along the immediate lime-granite contact, numerous smaller lenses, and scattered bunches, occur both in the crystalline limestones, and bordering altered granites, often at considerable distances from the contact.

The magnetite aggregates are granular in structure, and as a rule are comparatively pure. They usually terminate rather abruptly, against the enclosing rock, when this is limestone, and more gradually where they adjoin granite. Dike-like apophyses occasionally project for a few feet from the main body into the limestone.

The principal associated minerals are bornite, chalcopyrite, garnet, augite, epidote, clinochlore, and serpentine. The latter occasionally forms a matrix in which the magnetite grains are embedded.

*Hematite.*

Hematite is the principal mineral at the Pueblo mine, and occurs sparingly, usually in large tabular crystals, at the Rabbit-foot, Black Cub, and other claims.

The Pueblo hematite occurs both in a compact granular, and coarsely crystalline condition. It has suffered more from infiltrating surface water than the magnetite lodes. Portions of it are highly silicified, and the original copper sulphides have been largely altered to carbonates, oxides, and silicates.

*Limonite.*

This mineral occurs sparingly at all the mines, as a result of oxidation, but is nowhere abundant. It occasionally forms from decomposing garnets.

NON-METALLIC MINERALS.

*Quartz.*

This mineral occurs only in small quantities in the metamorphic rocks, and is seldom important as a gangue. Small quartz veins, cutting the granite, occur on the Rothsay, and at a few other points, but are not common. The large epidote masses which occur in the granite are usually accompanied by quartz, and the limestones, and more rarely the iron ores, are occasionally irregularly silicified.

*Calcite.*

A large proportion of the limestones of the district have been converted into coarse, whitish, granular calcite usually remarkably pure, by contact metamorphism. Near Hoodoo creek the calcite is exceptionally coarse, and breaks into rhombs, often half an inch or more across. The crystalline limestones weather easily, and talus heaps, of loose, sub-angular grains, occasionally form at the foot of the slopes.

*Feldspar.*

Feldspars occur occasionally as products of contact metamorphism, but seldom in quantity. On the Dawson road, near the Anaconda claim, the limestones include kidneys of, and are underlaid and separated from the granite by a rusty, fine-grained rock, noted in the field as a porphyrite. In thin sections it proved to be an altered limestone, made up chiefly of augite and feldspar, with subordinate quantities of epidote, calcite, chlorite, zoisite, and occasional grains of pyrite, hematite, magnetite, and chalcopyrite.

Feldspars, mostly untwinned, occur with augite in the gangue of the War Eagle ore body, and in portions of the altered rocks on the Copper King, Black Cub, and Best Chance claims.

*Garnet.*

Garnet is exceedingly abundant in the district. It occurs in scattered crystals, and in large masses, often simulating beds in their arrangement over large areas, both in the metamorphic limestones and in the adjoining altered granites. It also develops occasionally in the porphyrites and the porphyritic dikes.

Only one variety, the lime-iron-garnet andradite has so far been detected. The normal colour of the andradite is a dark brown. Specimens from the limestone cannot be distinguished in any way from those obtained from the granite. The bright yellow varieties, seen occasionally, are the result of hydration. Where completely altered the garnet passes into an earthy limonite.

Garnet, augite, and the light coloured amphiboles, tremolite, and actinolite, in varying proportions, form the ordinary gangue at most of the mines.

*Amphibole.*

White tremolite is a common gangue mineral at the Copper King, Grafter, War Eagle, and other claims: it occurs commonly in radiating bunches of bladed crystals, enclosing angular grains of bornite, and chalcopyrite. The usual associates are garnet and augite. Light green actinolite is a common secondary mineral, both in the limestones and granites.

*Pyroxene.*

Light green augite, in small crystals, is abundant everywhere in the metamorphic areas, and is often the principal secondary mineral present. It is a common gangue mineral, and is widely distributed, both in the limestones and granites. Large, well formed crystals of pyroxene, sometimes associated with scapolite, occasionally develop in the limestones.

### *Serpentine.*

Small quantities of dark greenish and yellowish serpentine, probably derived from the iron-magnesia minerals, are occasionally found in the altered limestones, and also in the magnetite aggregates.

### *Asbestos.*

Coarse asbestos occurs in small bunches on the Big Chief claim, and at a couple of other points. The probable derivation is from actinolite.

### *Clinochlore.*

Large tabular crystals of this dark green chloritic mineral are frequently found in the various magnetite masses.

### *Muscovite and Chlorite.*

These are found occasionally in the altered limestones.

### *Scapolite.*

This mineral occurs at a number of points, but is nowhere abundant. Well formed crystals of wernerite, of a light pinkish colour, are intergrown with pyroxene in the crystalline limestones on the Big Chief claim. At Pueblo No. 5 a white translucent scapolite, lined with green crysocolla, occurs as a gangue. The altered granites, on the Arctic Chief and other claims, are spotted over small areas with pinkish dots, which probably represent some variety of scapolite.

### *Epidote.*

This is a c[illegible]n secondary mineral in the altered granites, and less frequently [illegible]e crystalline limestones. It occurs both in separate crystals, associated with garnet and other secondary minerals, and in rounded green crystalline masses, which replace completely, portions of the granite. The large green masses usually enclose small bunches of milky white quartz. Specimens of a dark translucent epidote were obtained from the Anaconda workings.

### *Cancrinite.*

Small quantities of this wax-yellow mineral were observed in the Grafter mine. It occurs in thin layers, alternating with crystalline limestone, along one of the walls of the main ore body.

## DESCRIPTION OF PRINCIPAL MINES AND PROSPECTS.

### CLAIMS IN THE CENTRAL PART OF THE DISTRICT.

#### THE ARCTIC CHIEF.

The Arctic Chief is situated near the centre of the copper belt, at an elevation of 922 feet above Whitehorse, and 3,012 above the sea. A wagon road, 7·1 miles in length, connects it with the present railway terminus at Whitehorse. It was staked July 12, 1899, by Capt. John Irving, of Victoria, B.C. During the past season it was under bond to the Arctic Chief Copper Mines Company, with headquarters at Spokane, Wash., U.S.A.

*Geology.*

The Arctic Chief ore body is strictly a contact deposit between limestone, and a granitoid rock of variable composition, but mostly a hornblende granite. It is situated on the west side of a long irregular limestone bay, penetrating the granite area in a northerly direction. The limestones enclosed in the bay are similar to those along other portions of the copper belt. They are homogeneous crystalline rocks, white to greyish in colour, and as a rule remarkably free from inclusions and impurities, except near the contact with the intrusive. They have been welded into solid masses in places, but over most of the area the bedding is even and regular.

The bordering intrusive, in the vicinity of the ore body, is an altered quartz diorite, loaded with secondary minerals, among which garnet, augite, epidote, calcite, chalcopyrite, and magnetite are conspicuous. The dioritic phase is local, and the diorites pass towards the west and north into hornblende granites, and the sections show a further transition, at one point, into hornblende syenite.

The granites near the Arctic Chief ore body are exceptionally strongly mineralized. The affected area has a length of 1,000 feet, following the limestone contact, and a width of 400 feet. The mineralization is not uniform, and gradually diminishes away from the ore body. Where most intense, the original rocks are almost entirely replaced by alternating bands and masses of garnet, and a green augitic rock, classed as pyroxenite. The highly altered areas are often clearly traceable into unmistakeable granites, holding scattered crystals, and masses of garnet and epidote, and farther away into the unaltered variety.

The principal secondary minerals present are, garnet, augite, epidote, magnetite associated with bornite and chalcopyrite, actinolite, and scapolite. Epidote, while not occurring in such quantities as garnet, is found over a wider area. Magnetite occurs in small and large lenses, and is widely distributed in individual grains. Pink scapolite is conspicuous in places, but is not quantitatively important.

A few small inclusions of crystalline limestone occur in the altered granitic area, and may have influenced its mineralizaton. They contain the same secondary minerals as the granite, but in somewhat different proportions. Brown andradite is the chief mineral in both rocks, while epidote is relatively less abundant in the limestones than in the granite.

A number of large dikes occur in the vicinity of the Arctic Chief lode, cutting sharply across both limestone and altered granite. They were intruded after the formation of the ore bodies, and had no effect on the mineralization of the region

### *Development.*

The Arctic Chief ore body outcrops on rising ground, and has been opened up by means of a tunnel. Development work commenced in 1902, but has proceeded slowly. The present owners are making a systematic attempt to define the limits of the ore body. The principal workings consist of a tunnel, 230 feet in length, with short cross-cuts at intervals to the walls of the lode. The tunnel, with the exception of the first 65 feet, follows ore throughout. A shaft has been sunk near the centre of the ore body, to a depth of 50 feet below the main level; and an upraise to the surface, 65 feet in length, has just been completed. The lower part of the shaft is in altered diorite, and some drifting was done from the foot of it during the past season; to determine the character of the ore body at that level. The drifting was not extensive enough to give positive results.

### *Ore Body and Ores.*

The outcroppings of the Arctic Chief ore body at the surface, consist of a long lens of nearly solid, practically unoxidized magnetite, stained in places with copper carbonates. The hard surface section is grooved and striated by ice. The oxidized upper portion, if any existed, was removed during the glacial period, and since then little alteration has taken place.

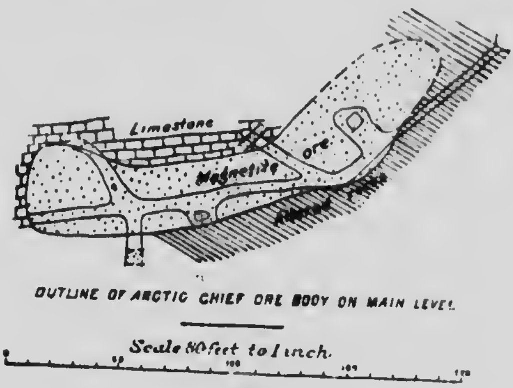



Fig. 1.

The ore body, as defined by the workings in the main level 65 feet below the surface, consists of a mass of magnetite, approximately 190 feet long, and from 25 to 40 feet in width. The mass is fairly regular in outline, but curves gently away from the granite contact, towards the west. Small parallel lenses have been disclosed by the workings at two points.

Little is known of the ore body below the main level. A centrally located shaft, 50 feet in depth, followed ore for 25 feet, then passed through altered diorite. A short drift to the north, from the foot of the shaft, penetrated mixed ore and altered rock for a few feet, and then entered limestone. A lens of well mineralized magnetite was encountered in a short cross-cut from this drift to the right, following the lime-diorite contact; but the work done was insufficient to show whether this represents the downward continuation of the main ore body, or the upper part of a new lens. A cross-cut to the left, along the lime-diorite contact, led to the discovery of a vein of rich silver-bearing tetrahedrite. The vein varies in width from a few inches, to a couple of feet, and had been followed about 40 feet, at the time of my visit. It does not appear on the surface, and this mineral is not known elsewhere in the camp.

The main magnetite lens of the Arctic Chief is enclosed directly between altered granite and crystalline limestone, at its eastern end only. The western portion of the lode bends away from the contact, and has developed entirely in limestone. Where the lode adjoins the granite, it is bordered by a zone of mixed ore, and diorite, largely replaced by secondary minerals. In the limestone it is more sharply defined, the dark magnetite usually ceasing abruptly against a wall of white limestone, either pure or containing only a few scattered grains of iron. Horses of nearly pure iron occur in the magnetite, and tongues of magnetite occasionally penetrate the lime for a few feet.

The magnetite varies greatly in texture, often passing in a short distance from a fine close-grained condition to a coarsely granular one. In certain areas, especially near the boundaries, the grains are separated by a soft serpentinoid mineral resulting from the hydration of secondary augite and actinolite. Clinochlore is also present, in places, in considerable quantities.

The principal economic minerals associated with the magnetito are the two copper sulphides, bornite and chalcopyrite. They occur in about equal quantities. They are distributed in grains and small patches throughout the whole lode, but are more abundant in some areas than in others. They occur both in separate grains and bunches, and are intimately intergrown.

Copper minerals, resulting from the alteration of the sulphides, are less plentiful at the Arctic Chief than at most of the other mines. The two copper carbonates, malachite and azurite, occur in small quantities at the surface and along the walls, but are seldom found in the interior of the lode. Cuprite, the red oxide, also occurs sparingly along the walls, and is usually associated with small quantities of native copper.

The iron sulphide, pyrrhotite, is occasionally found at this mine, in small masses enclosed in magnetite. The common zinc sulphide, sphalerite, also occurs, but is comparatively rare. No pyrite was observed.

The gold and silver values in the Arctic Chief are important. Assays invariably show gold in some quantity, the tenor ranging from traces, up to over two ounces per ton; and the whole lode probably averages over $4 to the ton. The gold values are not influenced by the copper percentage, since ores high in copper, often carry light values in gold. Specks of native gold are occasionally found, both in the ores and in the crystalline limestone. The silver tenor of the ordinary shipping ores averages about two ounces per ton; and assays of 147 ounces to the ton have been obtained from the tetrahedrite vein in the lower level.

The average copper percentage of the Arctic Chief lode is difficult to estimate, but probably somewhat exceeds 4%. A selected shipment of 140 tons, made in 1904, gave returns of 0·39 ounce of gold, 2·5 ounces of silver, and 7·22% of copper. A shipment of 83 tons, made during the past season, yielded 0·18 ounce of gold, 2·00 ounces of silver, and 5·37% of copper.

The following partial analyses of Arctic Chief ores were made at the Ladysmith smelter:—

| | Au | Ag | Cu | $SiO_2$ | Fe | $Al_2O_3$ | CaO |
|---|---|---|---|---|---|---|---|
| (1).. | 0·09 oz. | 2·45 ozs. | 8·13% | 8 60% | 44·84% | 15·78% | None |
| (2).. | 0·15 oz. | 2·15 ozs. | 7·75% | 4·40% | 50·61% | 12·62% | None |
| (3).. | 0·08 oz. | 1·12 ozs. | 3·57% | 6·60% | 53·20% | 13·28% | None |

Claims in the vicinity of the Arctic Chief, developed to some extent, include the Whitehorse, Golden Gate, the Suburban in the Corvette group, and the Verona.

The two former belong to the same company operating the Arctic Chief, and extend southward from it. They are situated in a granite area, destitute, as far as known, of limestone inclusions. The croppings on both claims are similar, and consist of partially decomposed granite, or diorite, seldom more than a few feet across, stained with iron and copper. Quartz, calcite, white mica, and chalcopyrite, are the principal minerals present. The workings consist of a few shallow pits.

The Suburban is situated east of the Arctic Chief, on a valley branching off from McIntyre creek. The lime-granite contact line passes through it, and is well exposed in the steep southern bank of the valley. The contact here is very sharp, and nearly vertical. The bordering granites are not mineralized, and are comparatively fresh. The limestones near the contact are altered mostly into fine-grained magnetite and serpentine, stained with copper carbonates. The altered zone has a width of 4 feet, and is followed by 6 feet of limestone, beyond which is a second, narrow, copper-stained bed.

North of the valley the contact is bordered by a narrow garnetized band, containing some bornite, chalcopyrite, and magnetite. A shaft 50 feet deep has been sunk on the deposit.

The Verona, northeast of the Arctic Chief, is underlaid mostly by basic granites or diorites, and limestones only occur as occasional inclusions. The granites bordering the inclusions are altered and partly replaced by epidote, garnet, augite, and other secondary minerals, including bornite, chalcopyrite, and magnetite.

A lens of magnetite, 30 feet in diameter, carrying copper minerals, occurs on the same claim. The lens is situated about 300 feet southeast of the line of limestone inclusions, and is surrounded by epidotized and garnetized diorite. No work has been done on it.

### THE GRA[illegible]

The Grafter ranks among the import[illegible]es of the district. It is situated about a mile north of the Arctic Chief, at an elevation of 730 feet above Whitehorse. A wagon road, 7·3 miles in length, connects it with the terminus of the railway at the latter point.

The Grafter was staked August 5, 1899, by Wm. Woodney, and in the following year a shallow shaft was sunk on a small oxidized area near the eastern boundary of the claim. In 1901, the claim was bonded to a local syndicate, and in that, and the following year, the shaft was continued down to a depth of 50 feet, and a southwesterly drift from the foot of the shaft was carried forward for a distance of 137 feet. Work was resumed in the spring of 1907, by Robert Lowe, the present owner, and a considerable quantity of ore was mined, and shipped during the season.

#### *Geology.*

The Grafter is situated in an area of narrow alternating bands of limestone and basic granite or diorite, all more or less altered. The intrusive here is a light to dark grey, rather coarse rock, mottled everywhere by dark areas, from a few inches to several feet in diameter. Most of these are basic segregations, but the angular character of a few of the larger ones suggests inclusions. Small light coloured aplite veins cut across both light and dark areas, and give the rock a very variegated appearance.

The intrusive is more basic than usual, the sections examined indicating a diorite, and in some instances, where augite is present in considerable quantities, a diorite-gabbro rather than a granite. The segregations consist mostly of hornblende, and a kaolinized plagioclase with some pyroxene, orthoclase, biotite and magnetite. Secondary minerals, mostly andradite, epidote, augite and actinolite, and copper sulphides, have developed in the granite near the limestone contact, and occasionally almost completely replace it.

The narrow limestone bands near the Grafter are enclosed in granitic rocks, and are altered into coarse, white and greyish marbles. In the immediate vicinity of the ore body, and at other points along the contact, the limestone is strongly mineralized, chiefly with andradite and varieties of pyroxene and hornblende. Besides these, a few nodules of serpentine, probably derived from the ferro-magnesian minerals, are also present. A peculiar, yellow banded variety proved on examination to be impregnated, in layers, with silica and iron.

*Workings.*

The workings on the Grafter consist of a shaft somewhat less than 100 feet deep, sunk on the ore body. At the 50 foot level, the ore body, which here describes a semi-circular course, has been followed for a distance of 150 feet, and has been stoped out in places nearly to the surface. A southwesterly drift, 137 feet in length, has also been run on the same level, to undercut a second surface showing. No ore was found in the drift, but more cross-cutting is necessary to prove definitely its existence, or non-existence, at this depth.

*Ore Body and Ores.*

The Grafter ore body has developed near the end of a small limestone tongue, which penetrated the main granitic area for a few hundred feet. The limestone at the extremity of the tongue is irregularly altered, portions of it being completely replaced by the ordinary assemblage of secondary minerals; while other portions, sometimes directly above, are almost free from them. The granites, or diorites bordering the limestone are also more or less completely replaced along a narrow intermittent zone by the same minerals which have developed in the limestones, and in some areas the present representatives of the two rocks are so similiar that they cannot be distinguished in the field.

The ore body worked at present has formed around a core of nearly pure, white crystalline limestone, 28 feet across. Development work has not proceeded far enough to show whether the central limestone mass is entirely encircled or not. At the 50 foot level, ore has been followed continuously around one end of the core, for a distance of 150 feet. The ore body here has a maximum width of

17 feet, and with the exception of one lean stretch, at the end of the oblong limestone core, is seldom less than 6 feet in width.

The continuation downwards of the ore body, to a depth of 90 feet at least, was proved by a shaft, sunk during the past season; and preparations were being made at the time of my examination to drift along it at that level.

The Grafter ores consist essentially of bornite and chalcopyrite, in varying quantities, disseminated through a hard garnet-augite-tremolite gangue. Malachite and azurite, cuprite and native copper, also occur in small quantities. Magnetite is common, but does not form large masses, and grains of pyrite, a somewhat rare mineral in the ore bodies, are occasionally found intergrown with the chalcopyrite. A small veinlet of quartz, carrying specks of native gold, was cut in sinking the shaft. The gangue minerals, besides those mentioned, include actinolite, cancrinite, and epidote.

The copper minerals are usually most abundant close to the unaltered limestone, and the grade of the ores decreases gradually, as a rule, away from it, until they become too lean to ship. Occasional grains and bunches of bornite and chalcopyrite occur throughout the whole altered area.

The shipments from the Grafter to date, mostly ma[illegible]ng the past season, have amounted to about 2,000 tons. The ore sh[illegible]l carried from 6 to 8 % of copper, and contained besides, valu[illegible] gold and silver, averaging about $3 per ton. It was practically unsorted.

The smelter returns of a couple of average shipments are as follows:—

| Lbs. | Moist. | Dry W't. | Copper. | Silver. | Gold. |
|---|---|---|---|---|---|
| 183,460 ...... | 1·5% | 180,708 | 7·83% | 1·88 oz. | 12 oz. |
| 221,370 ...... | 1·3% | 218,492 | 7·03% | 1·64 oz. | 10 oz. |

## THE BEST CHANCE.

This claim was staked on July 7, 1899, by Angus McKinnon, as the Last Chance, and relocated July 16, 1900, under its present name. It is now being developed by the company operating the Arctic Chief. It is situated in the valley of McIntyre creek, directly east of the Grafter, and is reached from Whitehorse by a wagon road seven and a half miles in length. Its elevation above Whitehorse is 600 feet, somewhat less than that of the Grafter.

The Best Chance contains the largest surface showing of cupriferous magnetite so far discovered in the district. The surface outcroppings of the mass, now being prospected, measure 360 feet in length, with a maximum width of 65 feet, and an average width of about 30 feet. The magnetite here, unlike the Arctic Chief ore body, has not been ground down by ice, and projects above the surface in a miniature range of low hummocky iron-garnet hills, from 6 to 20 feet in height.

*Geology.*

The geology of the Best Chance ore body is very similar to that of the Arctic Chief. It has developed along a granite-lime contact, and both these rocks are intensely altered in its neighbourhood. The limestone on the west is concealed, except at a few points close to the ore body, and it is not known whether it forms the extremity of a spur projecting from the main limestone area, or is a small inclusion in the granite. It is coarsely crystalline where exposed, and near the northern end of the lode is largely replaced by garnet and augite.

The band of altered granites, bordering the magnetite lens in the east, is much narrower than that in the vicinity of the Arctic Chief, barely measuring 50 feet. The principal secondary minerals developed in it are andradite, augite, actinolite, epidote, chalcopyrite, and magnetite. A small exposure of crystalline limestone, bordered by magnetite, occurs at one point in the altered intrusive area.

*Development.*

Very little development work has so far been done on the Best Chance. The workings consist of three shallow shafts, one 35 feet deep, with an easterly drift from its foot of 19 feet, and three opencuts, two of them in the altered zone bordering the magnetite lens in the east.

*Ores and Ore Body.*

Practically nothing is known of the character and shape of the Best Chance ore body, in depth. It is conspicuously exposed on the surface, the outcropping showing an oblong, fairly regular copper-stained magnetite mass, from 20 feet to 65 feet in width, continuously traceable for a distance of fully 360 feet. The magnetite is coarser grained than that of the Arctic Chief lode, and like it, although reddened in spots, has suffered little from surface oxidation. It is comparatively pure over large areas, but in places, especially along the eastern border, is intermingled with garnet and other secondary minerals. The lode is traversed irregularly, at all angles, by straight narrow partings, resembling jointage planes.

The copper minerals, associated with the magnetite, consist mostly of bornite and chalcopyrite, and various carbonates, and oxides derived from them. Besides these, small bunches of chalcocite are occasionally uncovered. The copper minerals occur in quantity, both in the magnetite, and in portions of the altered garnetized zone adjoining it in the east. Bands, several feet across, occur in the latter, impregnated with chalcopyrite, in grains and small masses.

No shipments of ore have so far been made from the Best Chance, and the general average tenor in copper is not definitely known. There is little doubt, however, that a large proportion of the whole magnetite mass, and considerable tonnage from the bordering garnetized zone, will exceed four per cent.

The values in gold and silver are small, seldom exceeding $2 per ton.

### THE RETRIBUTION.

This claim adjoins the Best Chance, on the north. The principal showing consists of a mass of large, angular, copper-stained, magnetite blocks, 50 feet in length, projecting through the drift. The blocks appear loose, but have evidently not moved far, and may be situated directly above their point of origin. They occur in the strike of a band of garnetized granite, which extends southward from the limestone contact 240 feet distant, and may have been derived from it. Further development work is needed to prove this fact, as the rocks in the vicinity are mostly concealed by drift.

Development on the Retribution is limited to a couple of shallow shafts, and two short tunnels driven into the bank of McIntyre creek.

### THE EMPRESS OF INDIA.

This claim is situated on McIntyre creek, north of the Retribution. Very little development work has been done on it, and it is important at present, chiefly from the fact that it is crossed by the sinuous, main lime-granite contact line, with its bordering zone of altered cupriferous rocks.

The limestones along the contact are altered into white, and greyish marbles, with irregular areas more or less completely replaced with secondary minerals: chiefly garnet, augite, actinolite, quartz, and calcite. Accompanying these, are occasional grains and bunches of bornite, chalcopyrite, magnetite, and molybdenite. The copper sulphides are largely altered, near the surface, into the carbonates and oxides. They are widely disseminated along the altered zone, but no large lens of pay ore has so far been discovered.

The granites, northeast of the limestone, are also mineralized, chiefly with garnet and epidote. The latter occurs in rounded, green masses, often 20 feet across, associated with small quantities of quartz and calcite.

#### THE SPRING CREEK.

The conditions on this claim are very similar to those of the Empress of India. The lime-granite contact line enters it from the latter, and is well exposed on the eastern part of the claim. In the western part it is concealed by drift.

The contact line is bordered on both sides by an unusually wide zone of altered rocks. The replacement minerals in the limestone consist mostly of garnet, with subordinate quantities of augite, actinolite, epidote, quartz, and calcspar, and in the granite of garnet and epidote.

The secondary minerals are accompanied as usual by the copper sulphides and magnetite, and at one point a small lens of rich bornite and chalcopyrite ore has been opened up by a shaft 43 feet deep. Further discoveries, on both the Spring Creek and Empress of India claims, are probable.

North of the Spring Creek claim, the drift covering becomes thicker, and more continuous, and the important lime-granite contact line is everywhere concealed, until the Pueblo claim in the northern part of the district is reached.

### CLAIMS IN THE NORTHERN PART OF THE DISTRICT.

#### THE PUEBLO.

The Pueblo mine is situated in the valley of Porter creek, near the northern end of the copper belt, at an elevation above the sea of 2,660 feet, and above Whitehorse of 570 feet. It is connected with the latter point by a good wagon road, 6·5 miles in length.

*History.*

The Pueblo copper concession was staked July 7, 1899, by H. E. Porter. The original discovery was made—so it is stated—not on the great copper-stained hematite mass which now gives it value, but on an unimportant quartz vein situated near the eastern boundary of the concession. It passed, soon after being staked, into the possession of the Whitehorse Copper Company, and was almost immediately bonded—with fifteen other claims owned by the same Company—to the British-America Corporation. Some development work was done by the latter Company; but the grade of the ore not proving satisfactory, the bond was thrown up. Early in 1906, the concession was bought by the Yukon Pueblo Mining Company, of Spokane, Wash., U.S.A., and a systematic exploration of the ore body has since been in progress.

*Development Work.*

The development work by the British-America Corporation consisted of sinking a shaft 70 feet deep, and drifting across the lode from the bottom of this. These workings were filled with ice and water at the time of my visit, and were inaccessible. The main drift extends about N. 19° W. from the bottom of the shaft, for a distance of 120 feet; and 30 feet from the face a shaft was sunk to a depth of 30 feet below the level of the drift. A second drift extends southwest from the bottom of the 70 foot shaft, for a distance of 35 feet.

The long drift, and both shafts, are reported to be entirely in ore, while the short drift penetrates crystalline limestone. Work under the present management has consisted mainly in determining the surface outline of the ore body, and in removing the boulder clay which covers the eastern part of it.

*Geology.*

The Pueblo ore body is situated near the granite-lime contact; but appears to be enclosed entirely in crystalline limestone. Just how close it approaches the actual contact is not known, as the country east of it is heavily drift-covered. The first outcrop of granite—here a hornblende variety—occurs in an easterly direction, at a distance of 380 feet, and in a northerly direction, at a distance of 270 feet. The limestone replaced by the ore body was originally cut by granitic dikes, and partially altered portions of these are still recognizable. A porphyrite dike, 2 to 4 feet in width, younger than the ore body, crosses it in a northerly direction. The dike has been attacked by solutions containing copper, and is everywhere decomposed and copper stained. Portions of it, for a considerable distance below the surface, have been removed, and the space filled in with gravel and boulders.

The limestone in the vicinity of the lode is highly crystalline, and contains a few garnets, but is not rich in secondary minerals. The granites immediately bordering the limestone, descending Porter Creek valley, are also only slightly mineralized. Farther down, at a distance of 840 feet from the main ore body, an area of intense mineralization occurs. The granites exposed on the right bank of Porter creek are filled with secondary minerals, mostly garnets, for a distance of over 300 feet. Some iron, in disseminated grains and small bunches, carbonates of copper, and occasional grains of chalcopyrite, are also present. Limestones occur on the opposite bank of Porter creek, and probably border the mineralized area, but the contact is concealed beneath the wash-covered flats of Porter creek.

### *Ore Body and Ores.*

The Pueblo ore body, as exposed on the surface by present development, is an irregularly shaped mass, 300 feet in length, and 170 feet wide, near the centre. The surface section measures approximately 33,000 square feet. It has been proved to a depth of 100 feet. The horizontal section at this level is not known, as it was only reached by a single shaft. At the 70 foot level the dimensions probably equal those at the surface, as a drift 120 feet in length from the foot-wall failed to reach the hanging-wall. The general dip of the lode has not been definitely proven. The foot-wall near the shaft has a northerly inclination of about 60°.

The ore is essentially a cupriferous hematite, deposited in limestone by a metasomatic replacement of the latter. The replacement has been nearly complete, only occasional traces of the original limestone remaining. The replacement of a granite dike which cuts the limestone is less perfect. Portions of the dike have been wholly or partially altered to iron and other minerals, but in places its original character is still evident.

The hematite grades in texture from a fine compact variety to a coarse glistening specularite. It is always slightly oxidized, even at the lowest depth reached, but the oxidation is confined, as a rule, to the surfaces of the grains, and no complete conversion of the hematite to limonite has been effected, except at a few spots on the surface. An irregular silicification of the lode, by surface waters, has produced important changes in the character of the ore. Certain areas have been converted by this agency into hard siliceous masses.

The copper sulphides associated with the hematites have suffered more by alteration than the hematite itself, and have been largely altered into carbonates, oxides, and silicates. No bornite has so far been found, although this mineral was probably present originally, as it is common throughout the district. Chalcopyrite has also disappeared from the greater portion of the lode, but has been preserved in a few limited areas. The carbonates of copper, especially the green carbonate, are the most important economic minerals in the portion of the lode explored at present. They occur disseminated throughout the hematite, and while more abundant in some portions than in others, nowhere form large, pure masses. The silicate of copper crysocolla is common, especially in the silicified portions. Cuprite, the red oxide, is sparingly distributed in veinlets, and small masses, through limited portions of the lode.

The alteration of most of the original copper sulphides into various secondary minerals, was accompanied by an impoverishment of certain portions of the lode, and an enrichment of others, especially near the periphery. The grade on this account is variable, ranging from 1% up to 10%, or more. The smelter returns from a shipment of 700 tons, taken from different parts of the lode, gave 5½% of copper, and 1¼ ounces of silver, while the average grade of the whole lode, so far as explored, probably approximates 4% in copper. The great excess of iron over silica—usually amounting to from 26%, to 30%—is an important feature of the ore.

The gold and silver values in the Pueblo ores are small, as a rule, although occasional assays show from $1 to $2 in gold, and from one ounce to three ounces of silver per ton.

No shipments were made from the Pueblo during the past season.

### THE COPPER KING.

The Copper King was staked July 6, 1898, by Jack McIntyre, and has the distinction of being the first claim located in the camp. It is situated about four miles northwest of Whitehorse, and is connected with that point by a wagon road, four and a half miles long.

Besides being the first claim staked, the Copper King was also the first claim on which a serious attempt at development was made. It was principally owing to the continued work of the owners—McIntyre and Granger—on it, and the results obtained, that interest in the camp was kept alive after the first excitement had subsided. Both these miners subsequently lost their lives in the district, McIntyre by drowning, and Granger by suffocation in a shaft.

During the past season this claim, with a large number of others in the district, was under bond to Col. Thomas, of Pittsburgh, Penn.; and exploratory work—which had been at a standstill for some time—was resumed.

*Geology.*

The Copper King, unlike most of the other important claims in the district, is situated, not along the edge of the granite area, but in a wedge-shaped tilted limestone fragment, originally about 600 feet in width and 1,200 feet in length, included in the granite mass, and surrounded on all sides by intrusive rocks. The limestone strikes in an easterly direction towards the Carlisle, and extends into that claim for some distance, just how far is not known, as the surface is concealed by drift.

The limestone is everywhere profoundly metamorphosed, and is now represented by isolated patches of light greyish, coarsely crystalline limestone, surrounded by rocks made up almost entirely of secondary minerals, principally brown garnet, augite, tremolite, actinolite, and epidote. Accompanying these, especially near the cores of unaltered limestone, are the copper sulphides; bornite and chalcopyrite. Magnetite, molybdenite, and occasionally free gold, are also found.

At certain points the secondary minerals are arranged in definite, but usually overlapping zones, the order of succession being limestone, bornite and chalcopyrite, tremolite, and garnet and augite intermingled. This succession, however, is not constant, as the copper sulphides and tremolite are often absent, and the limestone passes directly into a garnet, or garnet-augite rock, usually carrying some copper.

The granitoid rocks surrounding the limestone have also been altered, and partially replaced by secondary minerals, for varying distances back from the contact. The replacing minerals are principally garnet, augite, and epidote, similar to those in the limestone;

and where the replacement is complete the original contact line is completely obscured.

In the western part of the claim, along the valley of McIntyre creek, the granitoid rocks are thoroughly decomposed for 50 feet or more below the surface, and crumble down into a coarse sand. They are more basic here than usual, contain little or no quartz, and consist mainly of hornblende, augite, and feldspars too decomposed to determine. A specimen examined from the eastern part of the claim proved to be an augite syenite.

*Development.*

The principal workings are situated on a small plateau, 65 feet in height, overlooking McIntyre Creek valley on the east, and consist of an incline 130 feet in length following an ore shoot, and two drifts, one at 63 feet, and the other at 91 feet below the surface. The first of these starts at the bottom of Porter Creek valley, and has been driven in an easterly direction—mostly through altered granites and limestones—for a distance of 230 feet. It is connected with the incline by a short cross-cut. The second extends from the foot of the incline in an easterly direction for 65 feet. It is situated below the level of McIntyre creek, and was filled with water during most of tho season.

Other workings on the claim include a shaft or steep incline 65 feet in length, sunk during the past season on a mineralized band situated about 200 feet north of the main workings, and a third shaft, 40 feet in depth, sunk some years ago on a separate lens outcropping 200 feet south of the main workings.

*Ores.*

The Copper King ores consist of the two copper sulphides, bornite and chalcopyrite, distributed through a gangue of secondary minerals, consisting mainly of tremolite, augite, and garnet. Tremolite, although not the most abundant, is the most important gangue mineral, as the richest concentrations occur in it. Where the gangue is garnet, or augite and garnet, the copper minerals are usually more scattered.

The workahle ores occur in irregularly shaped lenses, usually resting on unaltered limestone, and in some instances enclosed in limestone.

The important lens opened up at the main workings has developed in altered limestone near the granite contact, and dips toward the contact at an angle of about 46°. It has been followed continuously along the dip for a distance of 130 feet, and to a vertical depth of 91 feet. The ore above the drift, at the 63 foot level, has been mostly stoped out, leaving an irregular chamber from 15 to 30 feet in length, and from a few inches, to 10 feet in depth, marking the shape of the original ore body. Ore continues to the foot of the incline, and a narrow band of rich ore, resting on a nearly flat limestone foot-wall, is also cut in the drift at the 91 foot level. The development work carried on during the past season, consisted principally in sinking a steep incline, to a depth of 65 feet, on a wide garnet-limestone band, coloured with copper carbonates, situated north of the main ore body, and separated from it by a barren zone. The shaft followed a small lens of rich bornite ore for the first 20 feet, then penetrated altered rocks, containing only scattered bunches of ore. Short drifts from the foot of the shaft failed to discover a workable ore body. Further drifting is required to thoroughly explore the mineralized band.

Other croppings occur at several points towards the southern part of the claim.

Shipments of high grade copper ores, totalling about 500 tons, have been made at various times from the Copper King, in addition to the considerable tonnage obtained during the operations of the past season. The ores shipped, are stated to have averaged over 15% copper, and contained besides from $2 to $3 in gold and silver.

Analyses of Copper King shipping ores, furnished by the management:—

| Au | Ag | Cu | Si | CaO | Fe |
|---|---|---|---|---|---|
| 0·025 oz. | 3·3 oz. | 22·82% | 33·22% | 5·00% | 6·85% |
| trace | 1·0 oz. | 6·21% | 35·76% | 25·45% | 4·55% |

### CARLISLE.

The mineralized limestone on the Copper King is traceable eastwards into the Carlisle, and an outcrop of copper stained rocks in the northeastern part of this claim has been opened up, with satisfactory results.

The workings consist of a shaft 50 feet deep, continued downwards by an incline 87 feet in length. At the 50 foot level a short cross-cut, 12 feet in length, to the north, encountered a small lens of rich ore. This has been drifted for a distance of about 50 feet, and 90 tons of ore, reported to average 22% copper, have been stoped out.

The ore is principally bornite, with some chalcopyrite enclosed in a tremolite gangue. The lens, as usual, rests on unaltered limestone, and is overlaid by limestone altered mostly into garnet and augite.

The Carlisle is owned by the Yukon Pueblo Mines Company. It was idle during the past season.

#### THE ANACONDA.

This claim is situated west of Porter creek, near the northern end of the copper belt. The principal development work consists of a long tunnel, driven westerly from the bottom of Porter Creek valley into the centre of a band of copper stained limestone which crosses the claim. No shipping ore was encountered, and the tunnel is now abandoned. During the past season the claim was under bond to Col. Thomas, of Pittsburgh, and a small amount of development work, principally stripping and trenching, was done.

*Geology.*

The Anaconda is situated along the eastern side of the main granite belt, and is underlaid largely by granite of the usual character. Limestone outcrops along the northeastern portion of the claim, and a spur of limestone from the main mass, 200 to 600 feet in width, crosses the claim in a diagonal direction. South of the limestone spur several small inclusions of lime occur in the granite.

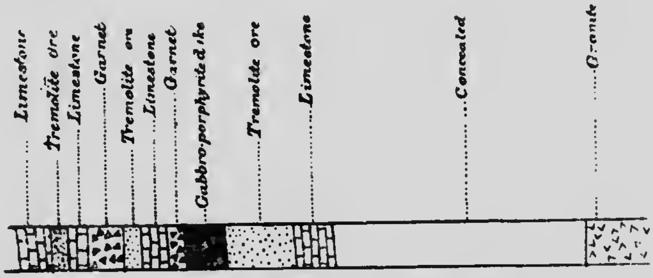
The limestone is coarsely crystalline, and in places is irregularly mineralized, chiefly with garnet, augite, tremolite, and epidote, usually associated with more or less bornite and chalcopyrite, and carbonates derived from them. The principal mineral development takes place, as a rule, some distance away from the granite, and not at the immediate contact.

The limestone dips steeply towards the granite, and the bedding seems to have exerted an important influence on the mineralization. Certain beds are largely replaced by garnet, while others alternating with them have been converted into tremolite, augite, and the copper sulphides, and others again have not been affected, or only slightly.

The bands replaced by tremolite are usually rich in copper minerals, and constitute the ores, while the garnet bands are only occasionally productive.

*Ores.*

Croppings of copper minerals occur at a dozen or more points on the Anaconda claim, but have only been opened up by shallow pits and trenches, and practically nothing is known of their behaviour in depth. A promising ore body, situated in the limestone, about 50 feet from the granite contact, was uncovered by trenching at a couple of points during the past season. The following section, measured along one of the trenches, illustrates the irregular manner in which the limestone is mineralized.




SECTION SHOWING ALTERNATING BANDS OF ORE, LIMESTONE AND GARNET

Scale 40 feet to 1 inch

10 0 10 20 30 40 50 60 70

Fig. 2.

The principal ore body has a width of 12 feet, and is overlaid by limestone, and underlaid by a gabbro-porphyrite dike. It consists mainly of tremolite, with subordinate quantities of augite and garnet, all carrying more or less bornite, chalcopyrite, and copper carbonates. Two small ore bodies, each about 3 feet in width, alternating with garnet and lime, parallel the main deposit, on the south. Other openings to the north and south, along the strike, show that the main lens carries its width for a distance of about 100 feet, and then narrows down. A shaft sunk on the lens to a depth of 30 feet, followed ore to the bottom.

Other lenses in the limestone, of more or less promise, have been trenched across, southwest of the one described, and one also occurs at several points in the bordering granite. The character of the croppings fully warrants further development work.

### THE RABBIT-FOOT.

This claim adjoins the Anaconda, on the southwest. It was staked July 7, 1899, by Ole Dickson, but has only been slightly developed.

The Rabbit's Foot is underlaid mostly by granite, holding occasional fragments of limestone. The principal croppings occur in a narrow limestone band enclosed in granite, which crosses into the claim from the Anaconda. Two short overlapping lenses of bornite ore, each from 3 to 7 feet in width, have been developed in the limestone. The bornite is sprinkled through an assemblage of secondary minerals, mostly tremolite, garnet, and augite. The granites bordering the limestones on the north are also altered in places into solid ridges of garnet.

The workings in the Rabbit-foot consist of two shallow shafts about 90 feet apart.

### THE WAR EAGLE.

This claim is situated about one and one-half miles north of the Pueblo, and is the most northerly claim being developed on the western side of the granite belt. It was staked July 16, 1899, by S. McGee, but no serious development work was undertaken until the claim came into the possession of the present holders, Messrs. Caldwell, Poyntz, Lucas, and Kesler, in 1907.

#### *Geology.*

The region in the vicinity of the War Eagle claim is mostly drift covered, and rock exposures are infrequent. The few seen, show that the eastern part of the claim is underlaid by granite, and the western part mostly by porphyrite, holding included fragments of limestone. The latter are altered, and partially mineralized along the granite contact, over an area fully 250 feet in width and 1,000 feet in length. The prominent secondary minerals in the altered area are garnet, tremolite, augite, and epidote, associated in places with bornite, chalcopyrite, and occasionally magnetite and molybdenite.

#### *Ores.*

The ore body at present being developed is situated close to the granite, and consists of an irregularly shaped mineralized area, mostly altered limestone, measuring 65 feet across, made up of alternating bands of tremolite and garnet, and a fine grained grey and dark feldspar-augite rock. The tremolite bands carry bornite and chalcopyrite in grains, small masses, and bunches, and constitute the principal ores. Copper minerals also occur in both the garnet and greyish augitic bands, but the percentage is lower than in the tremolite. A general sample taken along an open-cut crossing the lode, 45 feet in length, averaged 2·71 per cent copper. The values in gold and silver are small.

The croppings are situated on the summit of a slight incline, and the ore body is worked at present from a drift, which cuts the ore body at a depth of 23 feet. The drift pierces granite, all more or less altered for the first 76 feet, and at the time of my examination had been continued through the ore body for a distance of 44 feet. The section along the drift showed two tremolite-garnet bands, one 14 feet, and the other 10 feet in width, well mineralized with bornite and chalcopyrite, separated by 20 feet of lower grade material.

In addition to the large and important ore body now being prospected on the War Eagle, a number of smaller showings occur at various points in the area of metamorphic rocks bordering the granites, some of which appear worth investigating.

#### REGION NORTH OF THE WAR EAGLE.

No important mineral discoveries have so far been made north of the War Eagle, on the western side of the granite belt, and north of the Anaconda on the eastern side; although it has been solidly staked for several miles. This is largely due to the fact that, the drift covering becomes more general, and rock exposures are seldom seen. Also, while the granite continues northward, it is bordered mostly by porphyrites, which do not yield readily to mineralization, and limestone, the usual ore bearing rock, only occurs as an occasional inclusion in the porphyrite.

Discoveries of workable ore deposits in this portion of the copper belt are, therefore, unlikely, except at the few points, mostly drift covered, where the limestone inclusions touch the granite.

### CLAIMS IN THE SOUTHERN PART OF THE DISTRICT.

#### THE VALERIE.

This is the only claim in the southern part of the copper belt on which any considerable amount of development work has been done. It is situated west of the head of Miles canyon, and about three miles south of the Arctic Chief. A wagon road, two and one-half miles in length, to Wigan station, on the White Pass railway, was under construction during the season. The Valerie was staked August 22, 1899, by Gustave Gervais. The early development work consisted in sinking shallow shafts on the principal ore outcrops. From these 40 tons of high grade chalcopyrite ore were shipped, in 1904. Development work was resumed, in 1907, by Mr. A. B. Palmer, of Whitehorse, the present owner, and important discoveries of ore have since been made.

*Geology.*

The western portion of the Valerie is underlaid by limestone, and the eastern portion by hornblende granite, passing in places into a diorite, and it is along the ragged contact between these rocks that the ore bodies, as usual, have developed. The limestone is crystalline, and at various points along the contact is partially replaced by augite, garnet, chalcopyrite, magnetite, etc. The grano-diorites have also been mineralized, principally with garnet and epidote, for varying distances back from the contact, but otherwise, present no special features.

*Development.*

The workings consist of a shaft. or steep incline, 92 feet in length, affording a depth of 84 feet. From the foot of the shaft exploratory drifts, totalling [illegible] feet in length, have been run in various directions, partly in ore and partly in more or less altered lime and diorite. Besides the main shaft, two other shafts, each about 20 feet in depth, have been sunk on promising outcrops of ore, and some stripping has been done.

*Ore Body and Ores.*

Copper minerals in some quantity are seldom absent from the exposed portion of the lime-grano-diorite altered contact zone on the Valerie. They are irregularly distributed, rich areas alternating with comparatively lean stretches. The upper part of the present working shaft is sunk in an outcrop of chalcopyrite ore, 10 to 15 feet in width. At a depth of 25 feet, the ore ceased, and the shaft was continued through barren rock, mostly altered diorite, down to the present 84 foot level. Short drifts to the north and northeast, from the foot of the shaft, soon entered ore, and further exploratory work outlined a shoot of rich ore, approximately 50 feet in length, with a maximum width of 17 feet. An outcrop of ore on the surface, about 50 feet northwest of the shaft, probably represents the upward extension of this shoot. Three lenses, containing shipping ore, occur on the surface, while only one has so far been found in depth. It is probable that others will be discovered, when the present short drifts are extended farther along the limestone contact.

The ore shoot penetrated in the lower workings of the Valerie, is bordered on the south by a wide zone of altered and unaltered limestone, and altered diorite, impregnated with arsenical pyrites, in grains and bunches, associated with small quantities of chalcopyrite. The values in this belt are small, as the copper percentage is low, and assays show only traces of gold and silver.

The Valerie ores resemble those of the Pueblo, in consisting entirely of chalcopyrite, and derivative minerals. Accompanying these are mispickel, magnetite, augite, garnet, and calcspar. No bornite has been found. The chalcopyrite aggregates are larger than usual, and occasionally form solid bunches, several inches across.

The derived minerals, mostly malachite, azurite, cuprite, and native copper, are fairly abundant, down to the lowest depth reached.

No shipments have been made from the Valerie since 1904, when 40 tons of selected ore, obtained from the surface workings, were sent to the smelter. This ore is stated to have averaged 18 % copper, and over $5 in gold per ton.

A considerable quantity of high grade ore was obtained from the exploratory drifts run during the season.

The equipment at the mines consists of a 20 h.p. boiler; an 8 h.p. hoist; and a No. 5 Cameron sinking pump.

## LITTLE CHIEF.

This claim is situated a short distance north of the Valerie. It contains an important surface showing of cupriferous magnetite. Practically no work has been done on it, although it was one of the first claims staked in the camp. It was located September 15, 1898, by Andrew Oleson, and in 1899, was sold to Josia Collins, the present owner.

### *Geology.*

The Little Chief claim is underlaid over most of its area by hornblende granite. A band of limestone, a tongue from the main area, enters it from the north, and crosses the claim nearly parallel to the northwestern boundary. The limestone band has a width of from 100 to 400 feet. It is highly crystalline, and is filled in places with secondary minerals, principally brown and yellow garnets, and green actinolite, with some pyroxene and pink scapolite. The granite bordering the limestone is also well mineralized, over an exceptionally large area, mostly with brown garnets and green epidote, often associated with magnetite, quartz, and calcite.

*Ore Body and Ores.*

The principal showing on the Little Chief is situated 400 feet southeast of No. 1 post. At this point a nearly solid magnetite mass, over 100 feet long, and fully 50 feet in width, outcrops at the surface. The magnetite has developed in limestone along the granite contact. A dike from the latter is traceable part way across it, and is also partially altered to magnetite.

The magnetite is loose and broken at the surface, and is stained everywhere with copper carbonates, mostly derived from chalcopyrite. Serpentine, calcite, and garnet, are also associated with it.

A number of smaller lenses of magnetite, some of them over 20 feet across, occur on the same claim, both in the limestone and the altered granite.

The Little Chief claim is not being worked at present. The development work is represented by a few shallow open-cuts. The grade of the ore is not known.

## BIG CHIEF.

This claim adjoins the Little Chief claim on the north. It was staked September 15, 1898, by Wm. McTaggart, and is now owned by Josia Collins.

*Geology.*

Heavily bedded crystalline limestones, dipping steeply to the east, outcrop over a large part of the area of the Big Chief claim. A granite spur from the south cuts the limestones west of the centre line. Hornblende granites of the usual character outcrop along the eastern portion of the claim. Towards the north the limestones are intruded and replaced by an irregularly shaped area of hornblende porphyrite older than the granite.

*Ores.*

The ore bodies on the Big Chief consist of a number of copper bearing magnetite lenses, all situated in the limestones close to the granite contact. The largest lens seen, occurs near the centre line, about 500 feet from the southern boundary. Magnetite replacing limestone outcrops here, over an area 20 feet by 50 feet. The lode is probably considerably larger, as it is partially concealed. The magnetite is heavily copper stained, and is associated with serpentine, coarse asbestos, clinochlore, actinolite, and other secondary minerals. Two other smaller showings similar in character occur, one 200 feet, and the other 300 feet in a westerly direction. A second group of magnetite lenses outcrops near the southern boundary of the claim, close to the No. 1 post.

The copper contents of the magnetite lenses on the Big Chief are considerable, but the average tenor is not known. No shipments have been made.

The claim has not been worked for some years, and the early development work consists only of a short tunnel, 20 feet in length, and a few shallow pits and trenches.

### THE COPPER CLIFF.

This claim is situated on a small stream half a mile south of Hoodoo creek. It is underlaid partly by crystalline limestone and partly by hornblende granite, and both formations are cut by numerous porphyrite dikes.

The principal showing on the claim occurs at the northern contact of a small area of limestone with granite, and has been opened up by a short tunnel. The ore body is cut across, and partially destroyed by a large porphyrite dike. The section along the tunnel shows three bands of ore, each from 3 to 5 feet in width, separated by dike rock. The ores consist of bornite, and chalcopyrite, with garnet as the principal gangue mineral. Magnetite, tremolite, and various other secondary minerals are also present.

The value of the Copper Cliff ore body depends largely on the relative dips of the dike and the lode, and this could not be determined in the present limited workings.

### THE NORTH STAR, KEEWENAW, ETC.

This claim is situated about a mile south of the Vale[illegible], near the extremity of a deep embayment of limestone in the main granite area. The workings consist of two pits, about 200 feet apart, each about 10 feet deep. One of these is sunk in an ore body about 6 feet in width, consisting mostly of magnetite and calcite, flecked through with grains of chalcopyrite and bornite, and enclosing occasional masses of chalcopyrite, some of them 12 inches in diameter. The gangue minerals present include garnet, augite, tremolite, epidote, serpentine, and clinochlore. The second pit shows a copper stained magnetite lens, 3 to 4 feet in width, dipping towards the granite.

The showings occur along the lime-granite contact, and both rocks are altered and mineralized over a considerable area. The limestones are coarsely crystalline, and are dotted in places with small magnetite lenses, often only an inch or two in length. The granites, for some distance south of the croppings, are heavily garnetized.

In addition to the claims described, the Buckingham, the Hoodoo, the Jo Jo, the Yukon Belle, the Josephine, and others distributed along the copper belt, between the Valerie and the Copper Cliff, contain ore out-croppings of more or less promise. The development work is limited to a few shallow test pits and trenches.

No discoveries of importance have so far been made from the Copper Cliff south eastward to the Keewenaw claim, east of Wolf creek, a distance of nearly three miles. The region between these two claims is underlaid by granites, porphyrites, and basalts, and limestone, the usual ore bearing formation, is absent.

On the Keewenaw the granite is again associated with limestones, and both rocks are altered and mineralized in places. Copper stained rocks outcrop at several points on the claim, both in the granite at some distance from the contact, and along the contact, and have been opened up by surface cuts and shallow shafts. Bornite occurs at several of the openings.

From the Keewenaw east to the Black and Brown Cubs, at the extreme southeastern end of the copper belt, the country is heavily drift covered, and rock exposures, except in the valley banks, are seldom seen. A few prospects occur in this stretch.

In the vicinity of the Black and Brown Cub claims the drift covering becomes less continuous, and the underlying rocks are occasionally seen. They consist of granites and limestones, both of which are altered and mineralized in the usual manner, along the contact. The altered garnetized zone has a width of fully 300 feet, and is heavily copper stained at a number of points.

The development work on the claims consists of some stripping, and two shafts, one 62 feet in depth. The latter is sunk through a garnet-augite-tremolite rock, carrying some rich bornite ore.

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CANADA

# DEPARTMENT OF MINES

## GEOLOGICAL SURVEY BRANCH

HON. W. TEMPLEMAN, MINISTER; A. P. LOW, LL.D., DEPUTY MINISTER;
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715. Altitudes of Canada, by J. White. 1899.
*972. Descriptive Catalogue of Minerals and Rocks, by R. A. A. Johnston and G. A. Young.

## YUKON.

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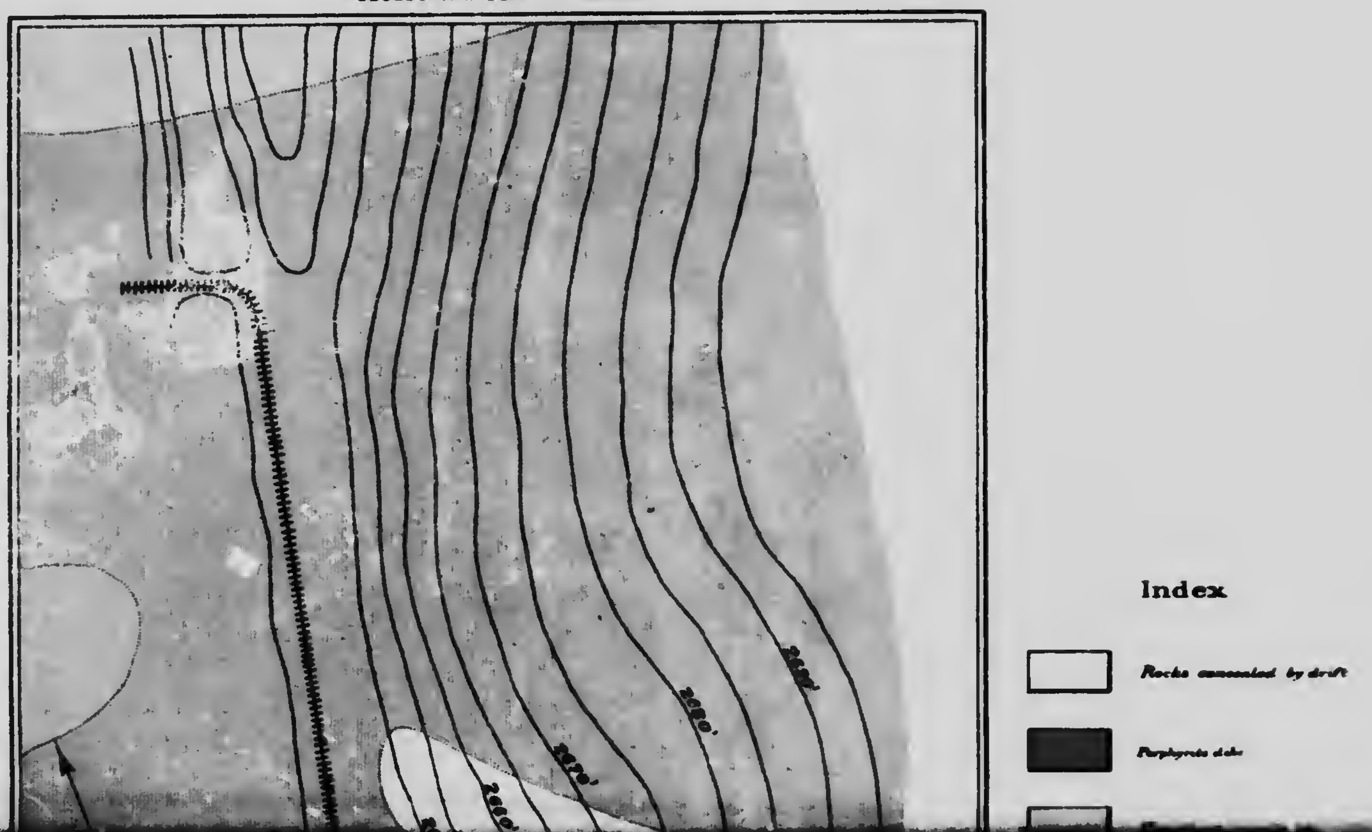

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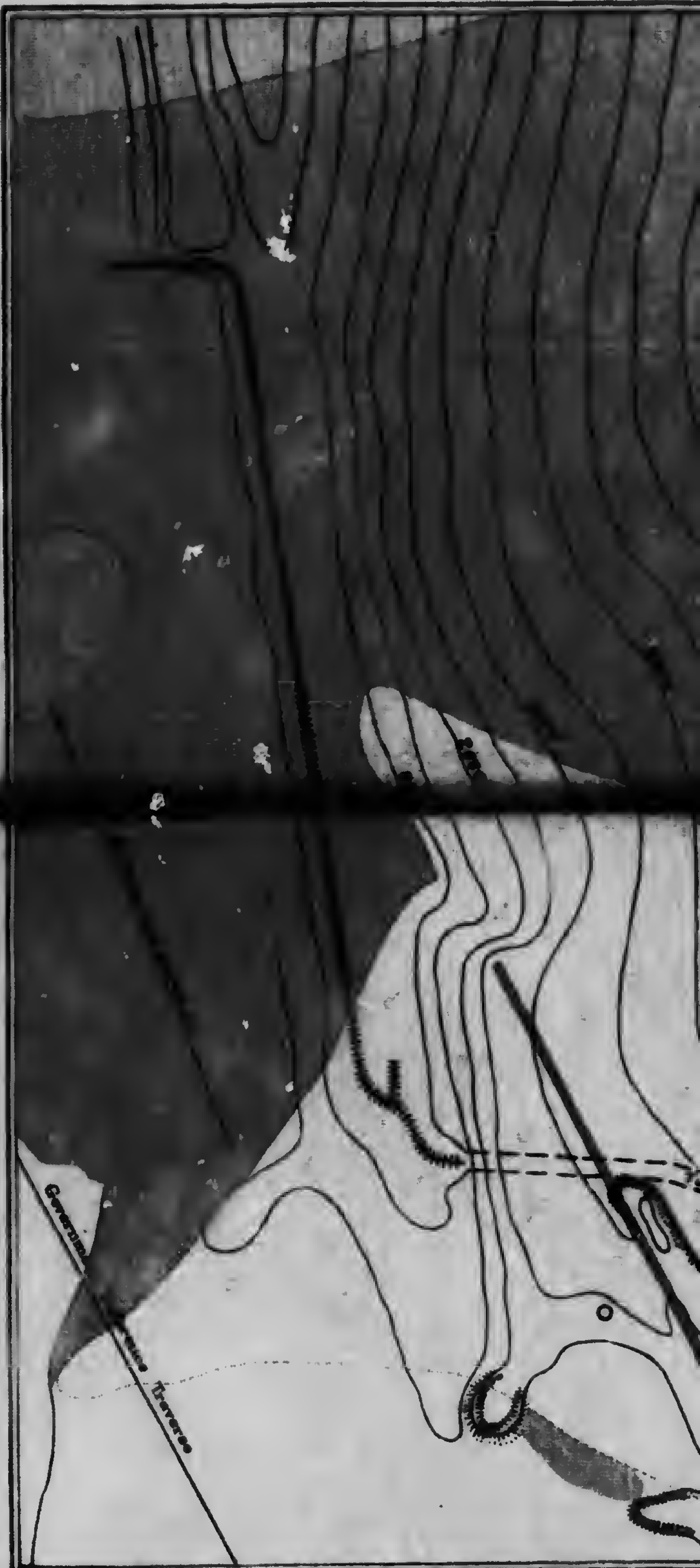


Surface

**PUEBLO MINE**

Whitehorse Copper Belt, Yuk

*To illustrate Report by*

R. G. McCONNELL, B.A.

*Scale 60 feet to 1 inch*

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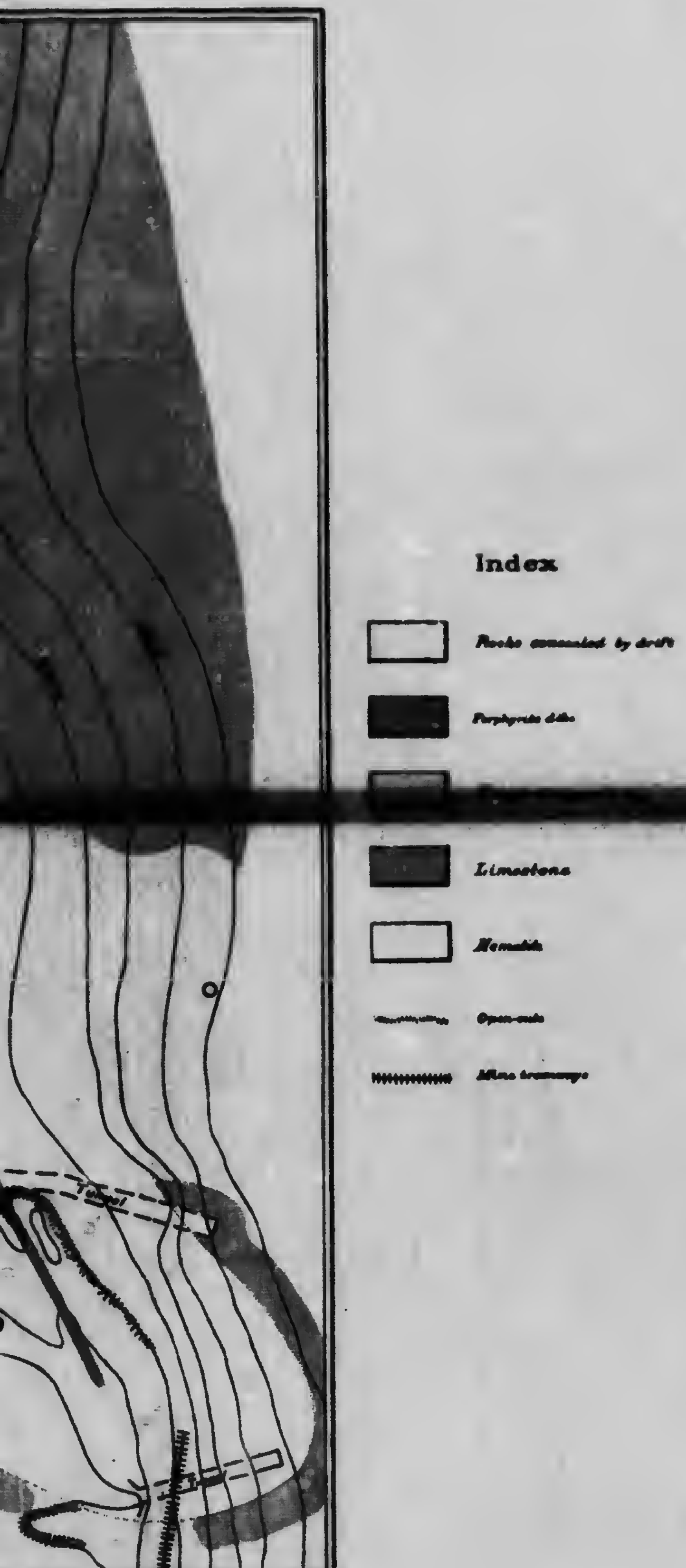


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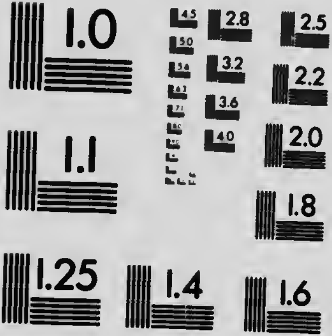

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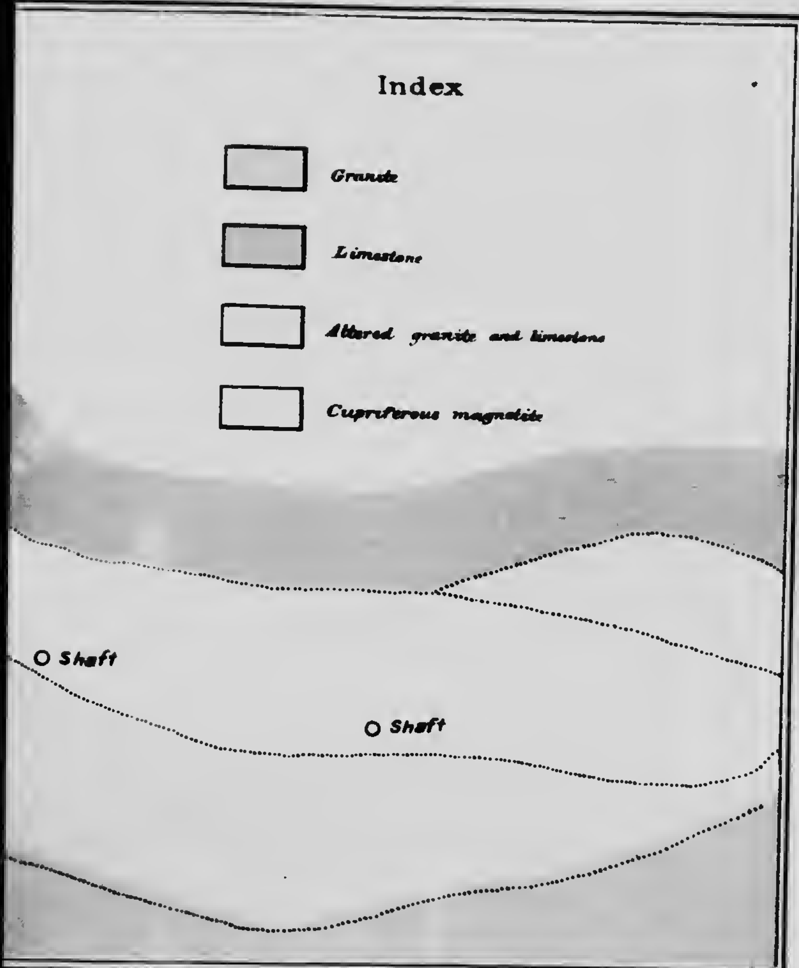


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per Belt, Yukon.

Report by

ELL, B.A.

to 1 inch

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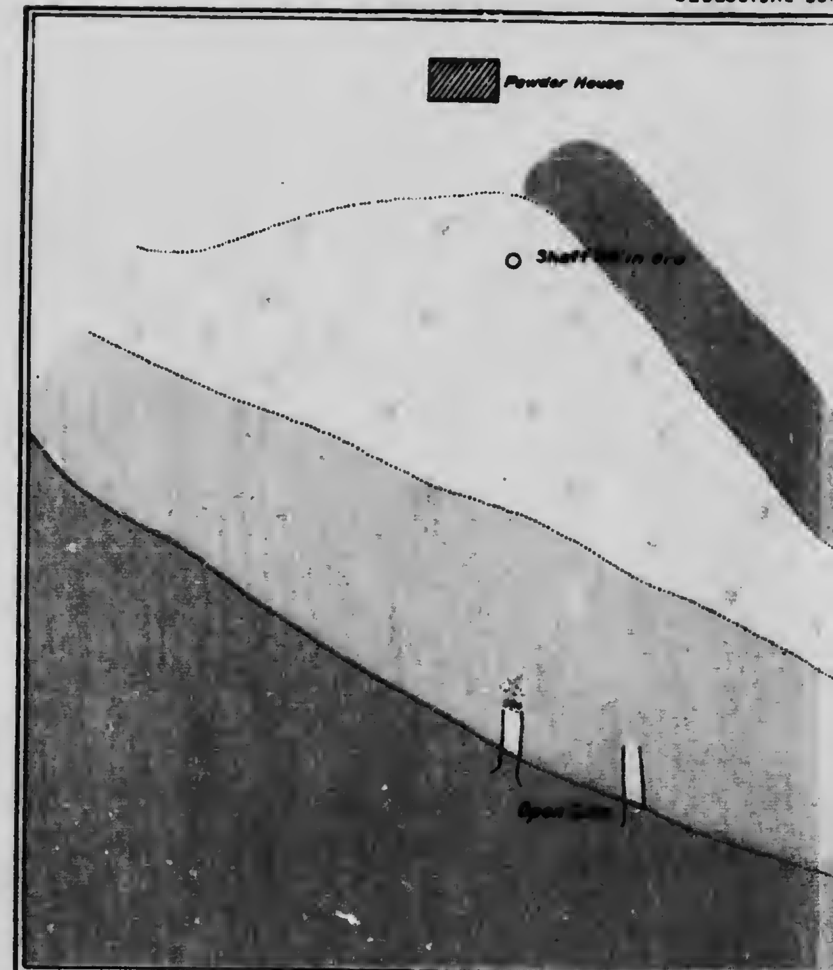


BEST CHANCE

Whitehorse Coppe

*To illustrate R*

R.G.McCONNE

*Scale 40 Feet t*

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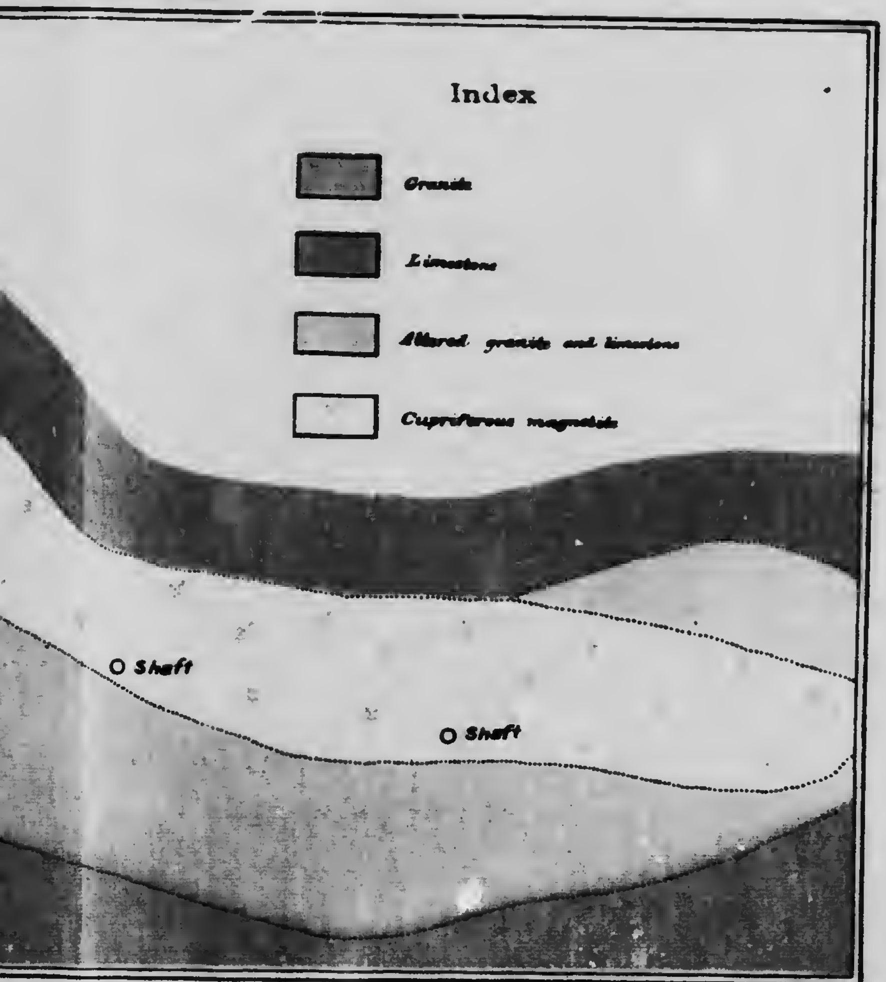


No. 1048

HANCE ORE BODY

Copper Belt, Yukon.

*ustrate Report by*

.McDONNELL, B.A.

*e 40 feet to 1 inch*

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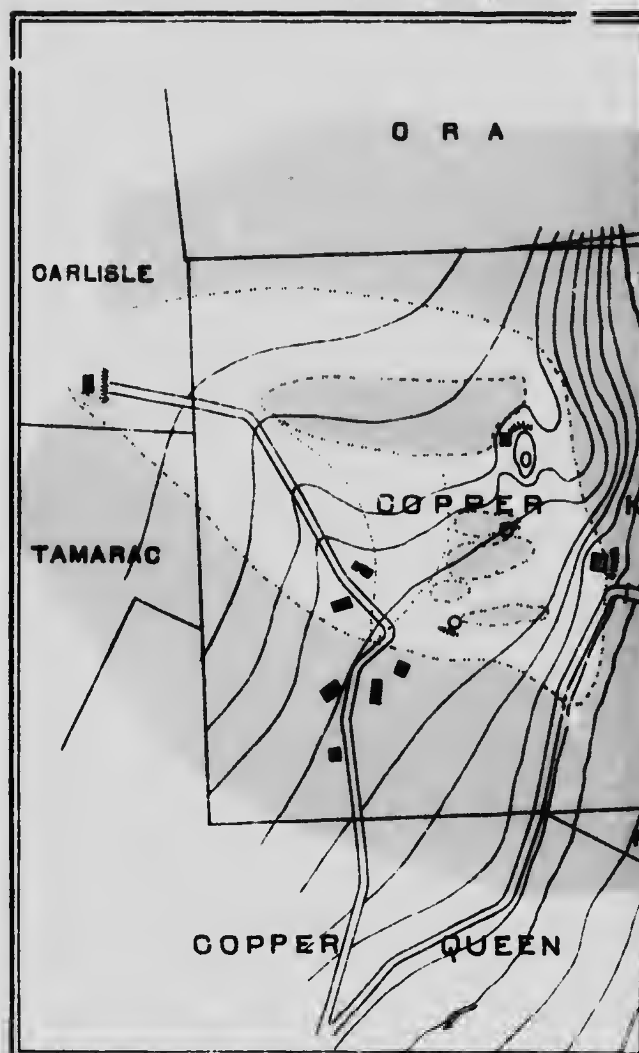


SURFACE AT COPPER KI

Whitehorse Copper Bel

*To illustrate Report b*
R. G. M^c CONNELL, B.A.

*Scale 400 feet to 1 inc*

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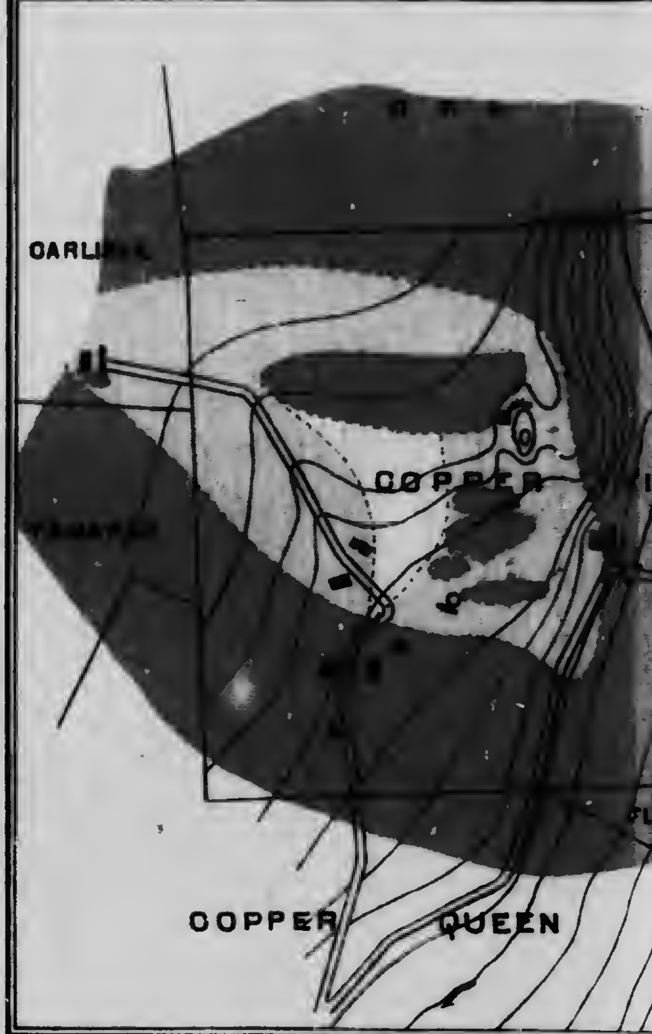


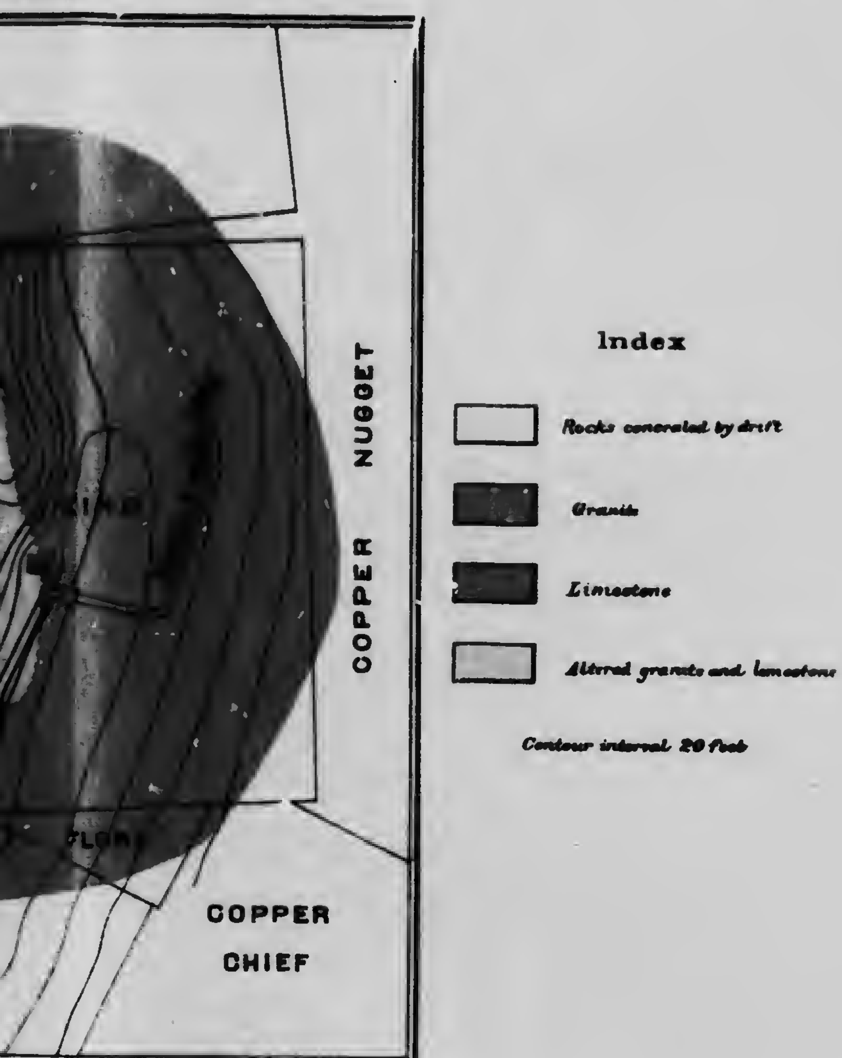

SURFACE AT COPPER KING

Whitehorse Copper Belt,

*To illustrate Report by*
R. G. McCONNELL, B.A.

*Scale 400 feet to 1 inch*

F MINES
BRANCH

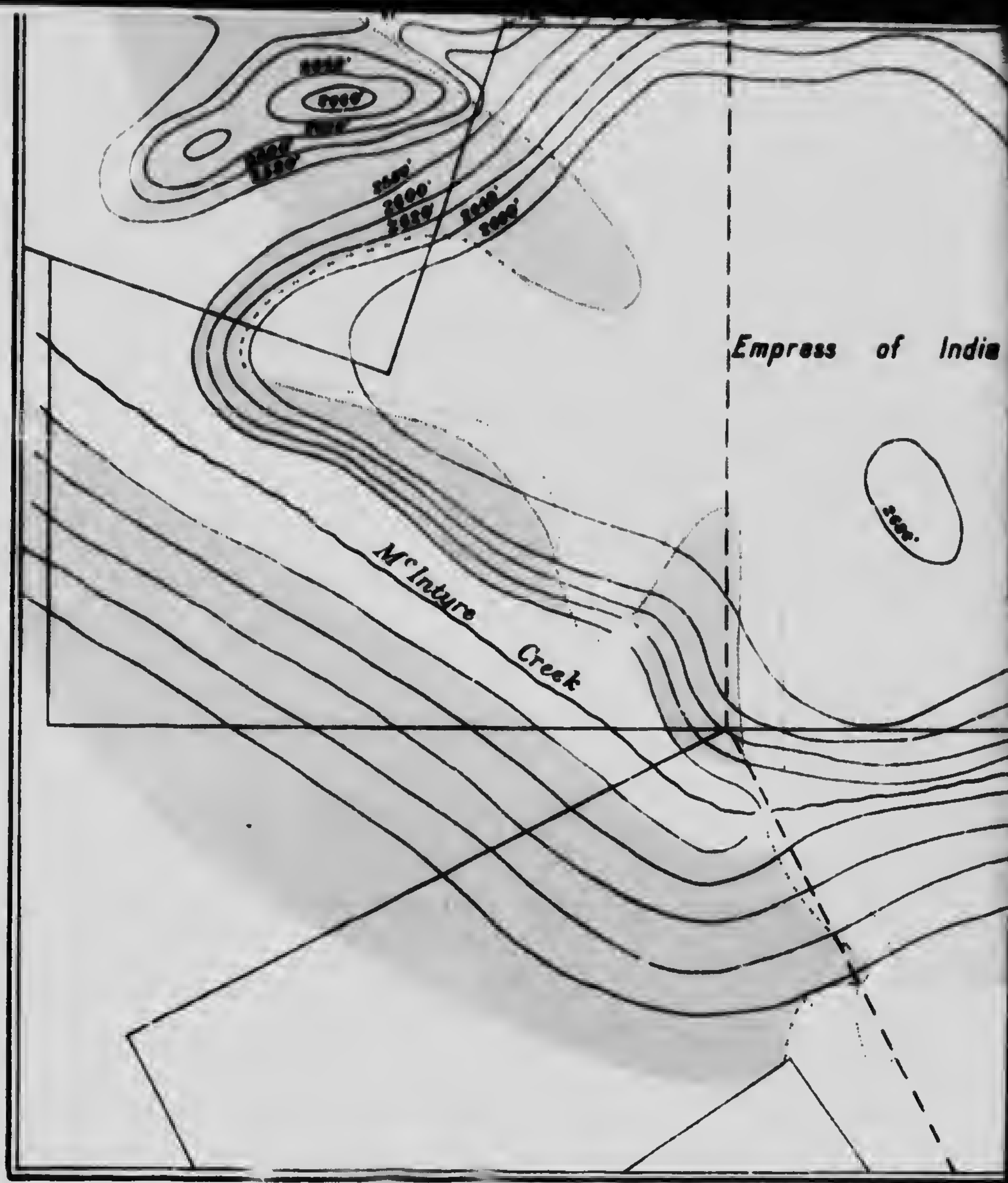



No.1047

R KING MINE

Belt, Yukon.

port by
., B.A.
o1inch




**EMPRESS OF INDIA MINER**

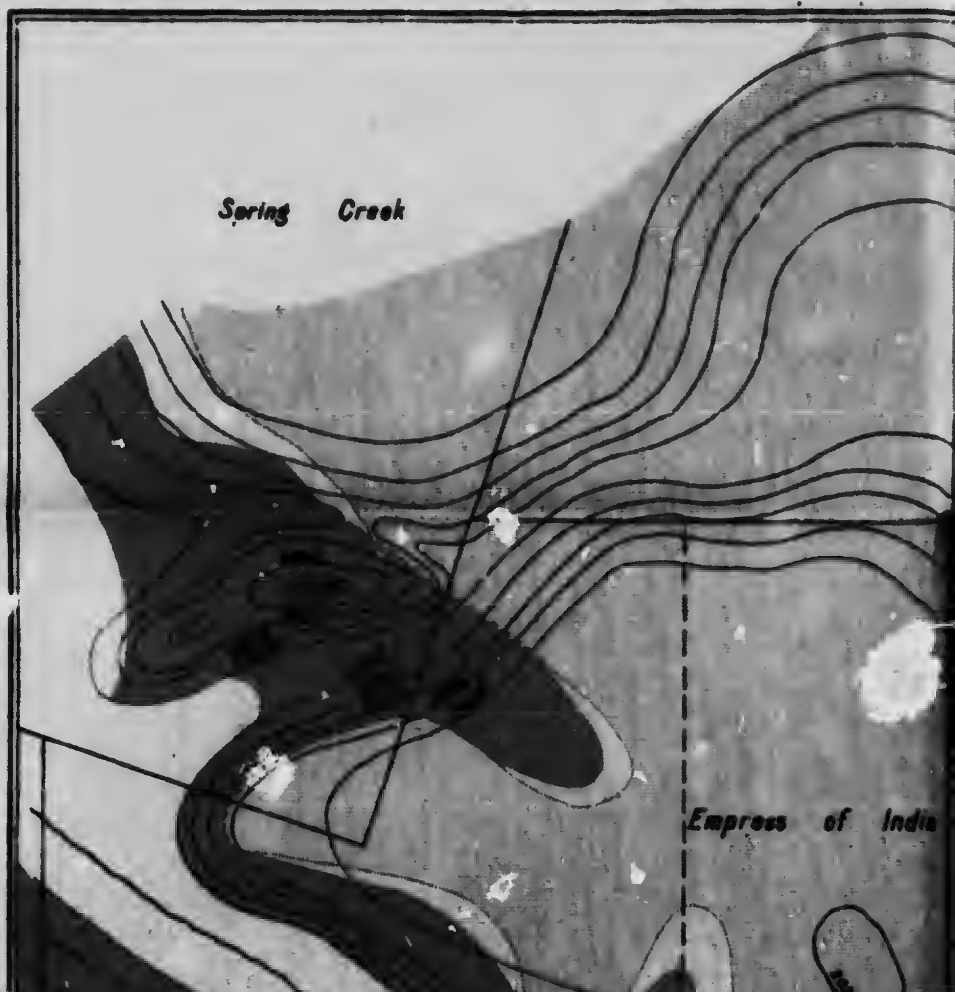
**Whitehorse Copper Belt,**

*To illustrate Report by*
R. G. M^c CONNELL, B.A.

*Scale 200 feet to 1 inch*

100 0 100 200 300

CANADA
DEPARTMENT OF MINES
GEOLOGICAL SURVEY BRANCH



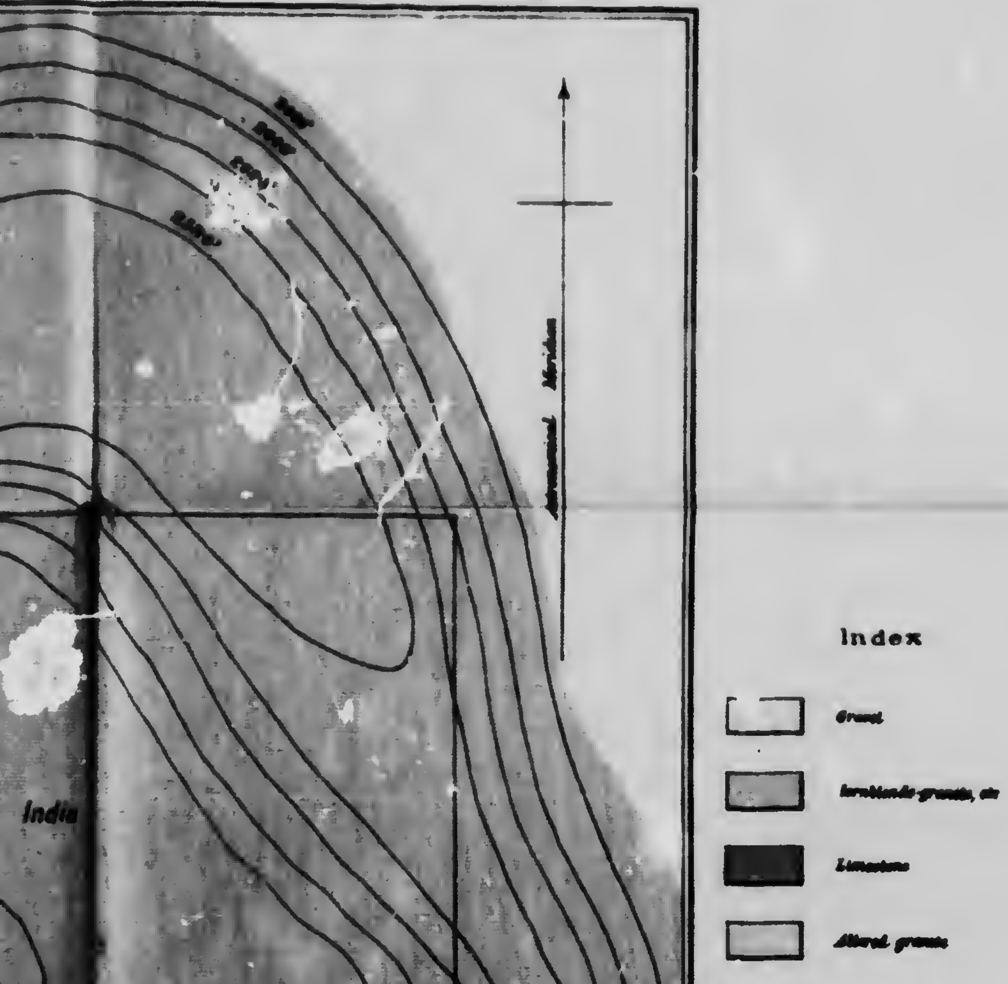

EMPRESS OF INDIA MINERAL

Whitehorse Copper Belt, Y

To illustrate Report by
R. G. McCONNELL, B.A.

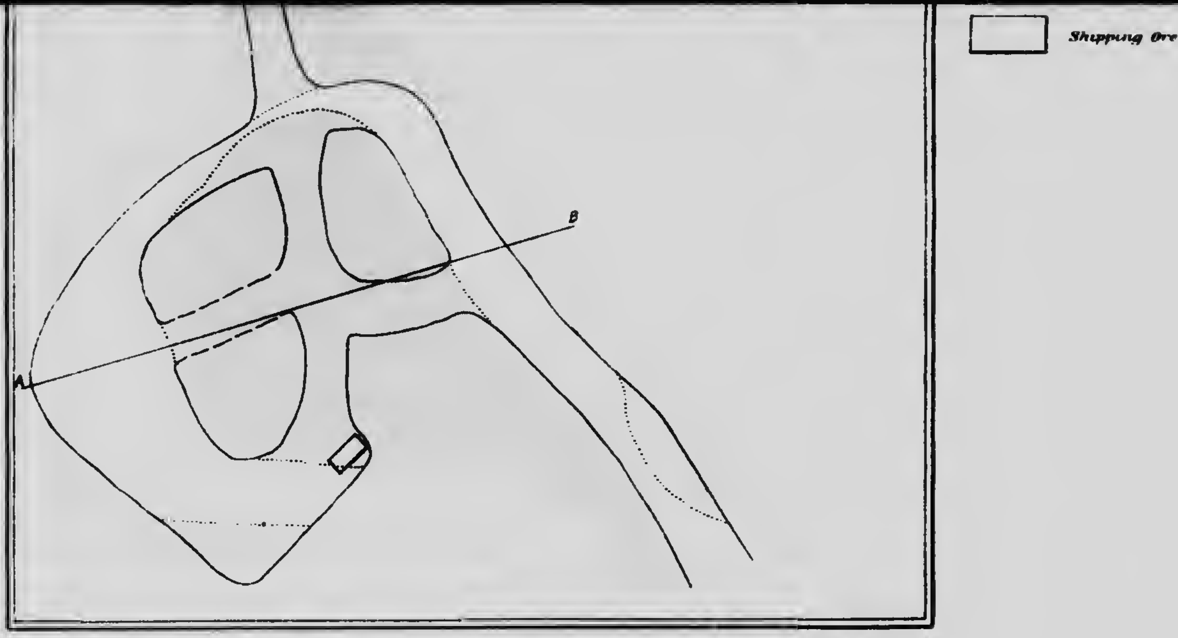
Scale 200 feet to 1 inch

MINES
RANCH




No. 1043

INERAL CLAIM
Belt, Yukon.




No. 1045

GRAFTER MINE

Whitehorse Copper Belt, Yukon.

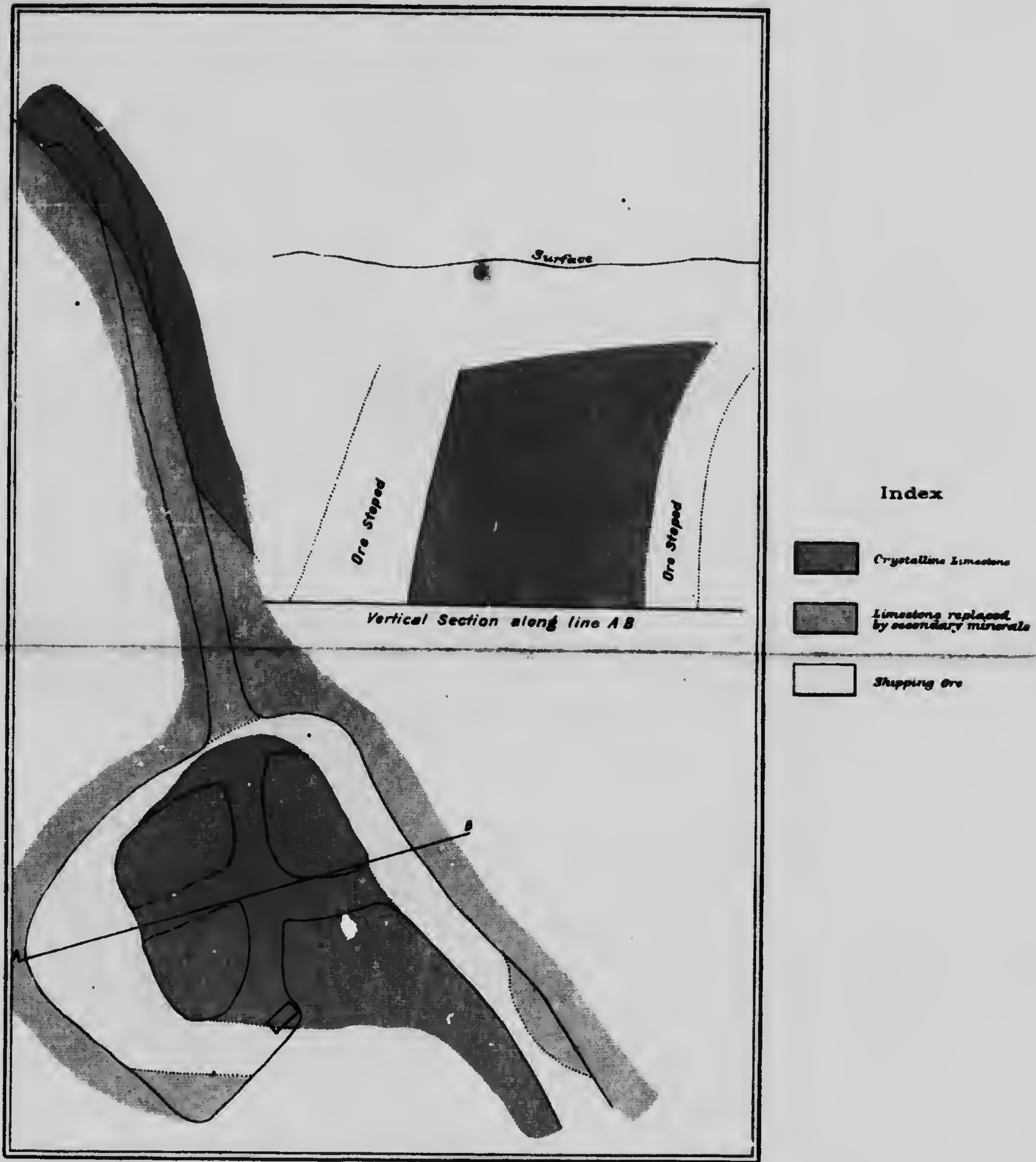
*Workings at 50 Foot Level*

*To illustrate Report by*
R. G. McCONNELL, B.A.

*Scale 20 feet to 1 inch*

5 0 5 10 15 20 25 30 35

CANADA
DEPARTMENT OF MINES
GEOLOGICAL SURVEY BRANCH




No. 1045

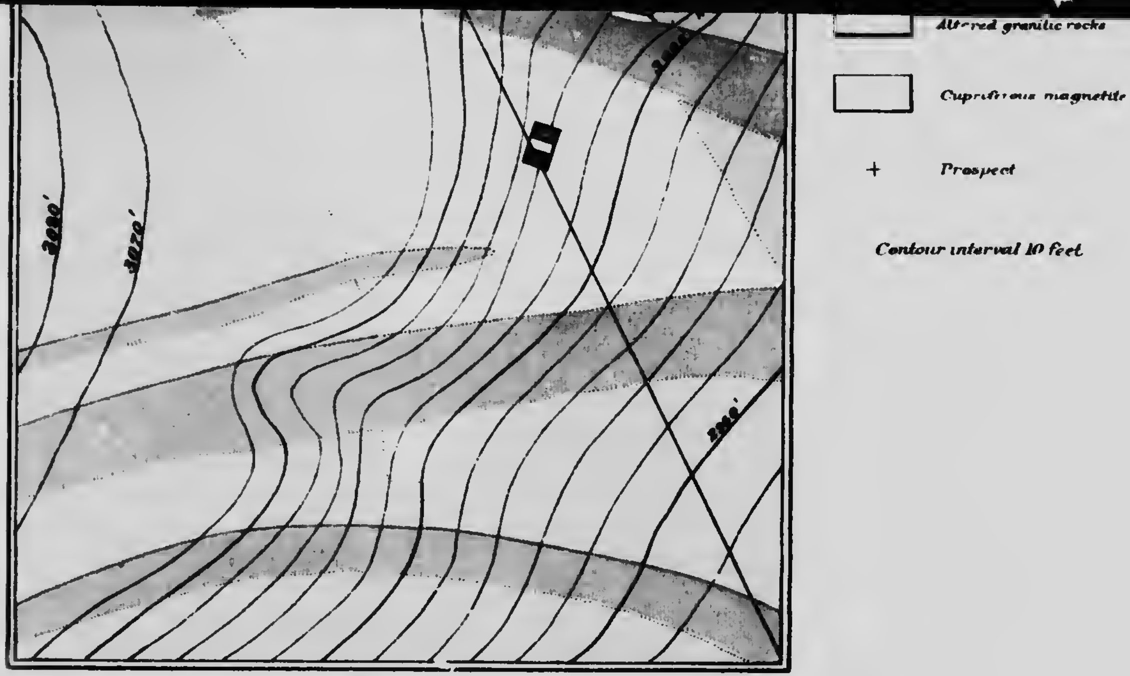
# GRAFTER MINE

Whitehorse Copper Belt, Yukon.

*Workings at 50 Foot Level*

*To illustrate Report by*
R. G. McCONNELL, B.A.

*Scale 20 feet to 1 inch*
5 0 5 10 15 20 25 30 35




No. 1044

# SURFACE AT ARCTIC CHIEF MINE

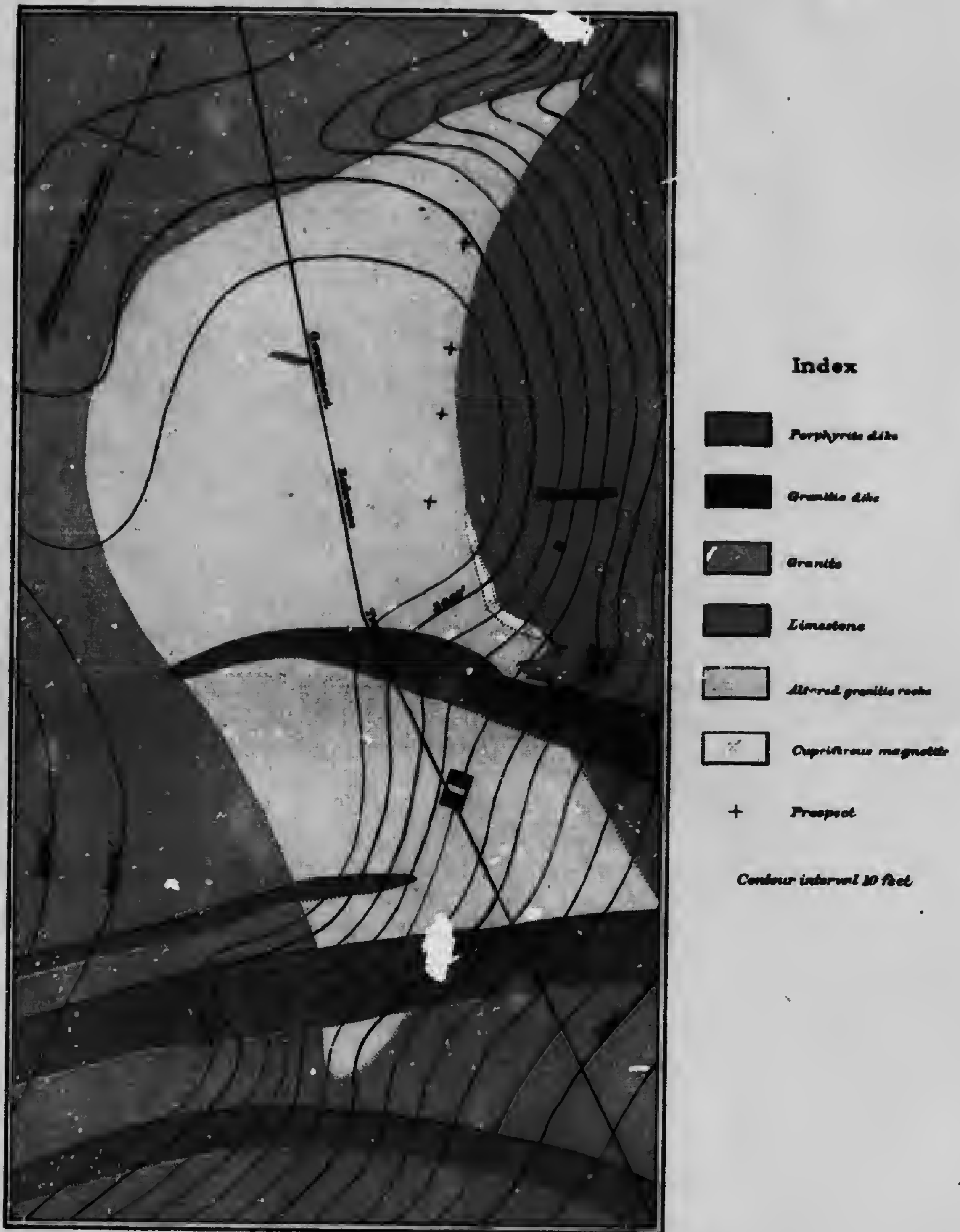
## Whitehorse Copper Belt, Yukon.

*To illustrate Report by*
R. G. McCONNELL, B.A.

*Scale 160 feet to 1 inch*

50 0 50 100 150 200 250 300

CANADA
DEPARTMENT OF MINES
GEOLOGICAL SURVEY BRANCH




No. 1044

SURFACE AT ARCTIC CHIEF MINE

Whitehorse Copper Belt, Yukon.

*To illustrate Report by*
R. G. McCONNELL, B.A.

*Scale 100 feet to 1 inch*

INES

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HON W. TEMPLEMAN, MINISTER, A P LOW, DEPU
R W BROCK, ACTING DIRECTOR

1909.


C.O. Senécal, B.A. Sc. Geographer and Chief Draughtsman
O.E. Prud'homme, Draughtsman

Scale. 1 mile to 1 inch

Geological and Topographical
of
WI ORSE COPPER
YUKON TERRITORY

To illustrate Report by
R.G. McCONNELL, B.A.
1907.

F MINES
BRANCH

OW, DEPUTY MINISTER
RECTOR

Legend

Rocks concealed by drift
Basalt
Porphyrites
Granites etc
Limestones

Triangulation Stations
Roads
Trails
Bridges
Marshes
Tunnels
Contours based on elevation of rail at Whitehorse station contour interval 20 ft
Depression Contours
Heights in feet above sea level

Shafts
Prospects

Sources of Information

Lewes river from transit-micrometer traverse by Wm Ogilvie D.L.S. 1887

Government reference traverse and traverses of roads from Whitehorse to Grafter and Copper King mines by H.G.Dickson,D.L.S.

Traverse of road to War Eagle mine by F.R.Maclaren, Geological Survey.

White Pass and Yukon Railway from official plans.

Topography from Stadia and plane-table surveys, and compilation of map by F.R.Maclaren, 1907

Geology by R.G.Mc Connell.

No 1041

aphical Map

PER BELT

TORY

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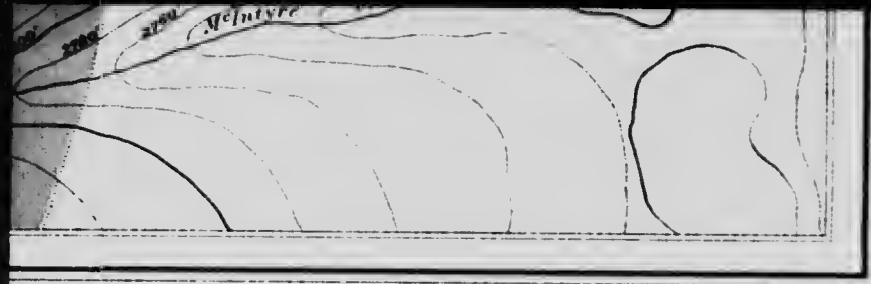
S.A.




*Topography by F. H. Maclaren, B.Sc.*
*Geology by R. G. McConnell, B.A.*

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ction of
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TORY
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B.A.

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No. 1026

*Price 10 cts.*

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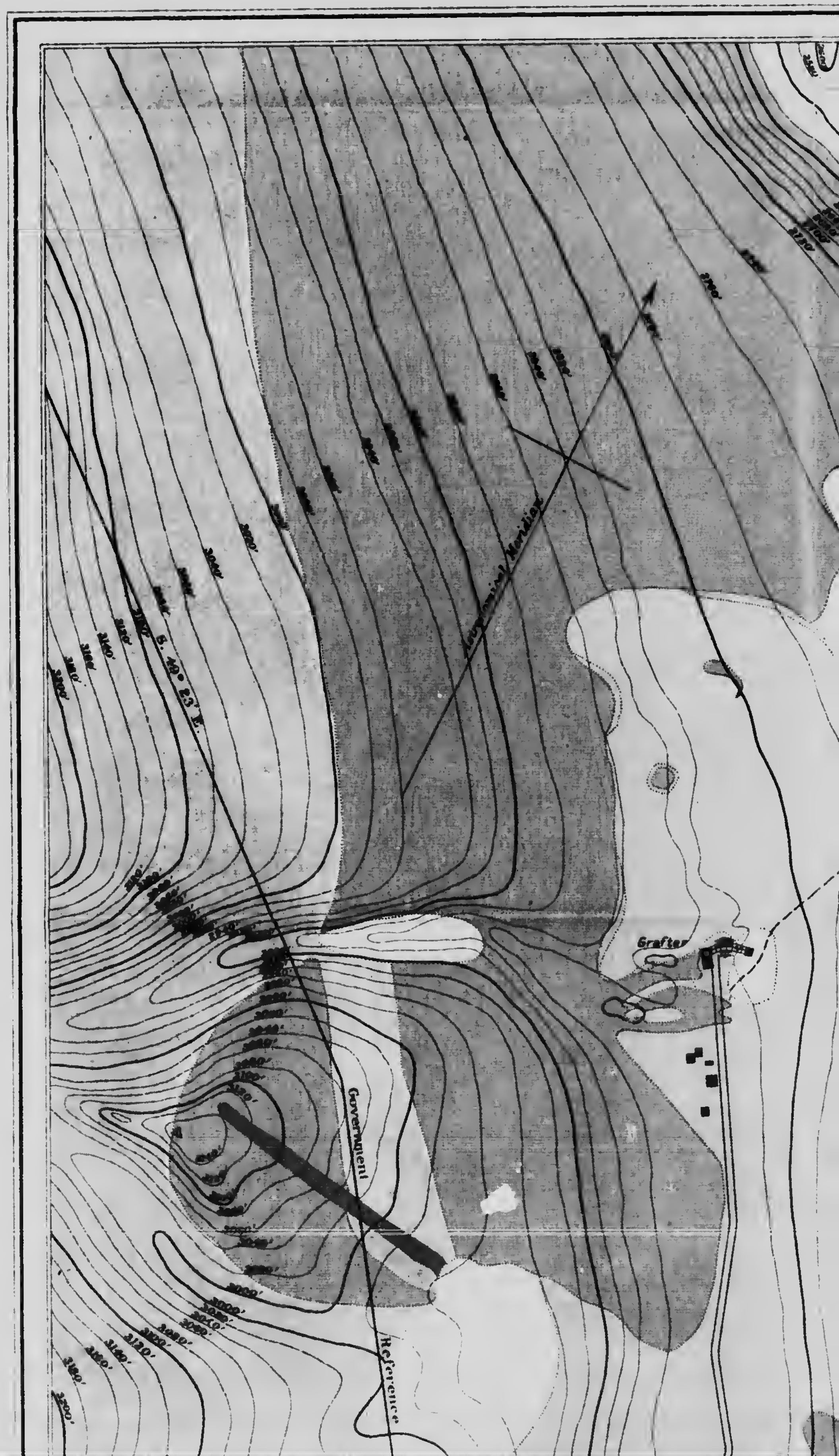
R.W. BROCK, ACTING DIRECTOR

1909.



OF MINES

EY BRANCH

P LOW, DEPUTY MINISTER.
DIRECTOR


## Explanation of Colours and Signs

*Rocks concealed by drift*

*Porphyrite dikes (dikes only partially mapped)*

*Porphyrite.*

*Hornblende-granite passing in places into grano-diorites, diorites and syenites.*

*Limestones*

*Altered contact zones*

*Magnetite*

*Roads and buildings*

*Trails*


C-O. Senécal, B.A Sc., *Geographer and Chief Draughtsman*
O.E. Prud'homme, *Draughtsman*

Geological and Topo
Map of Central Por

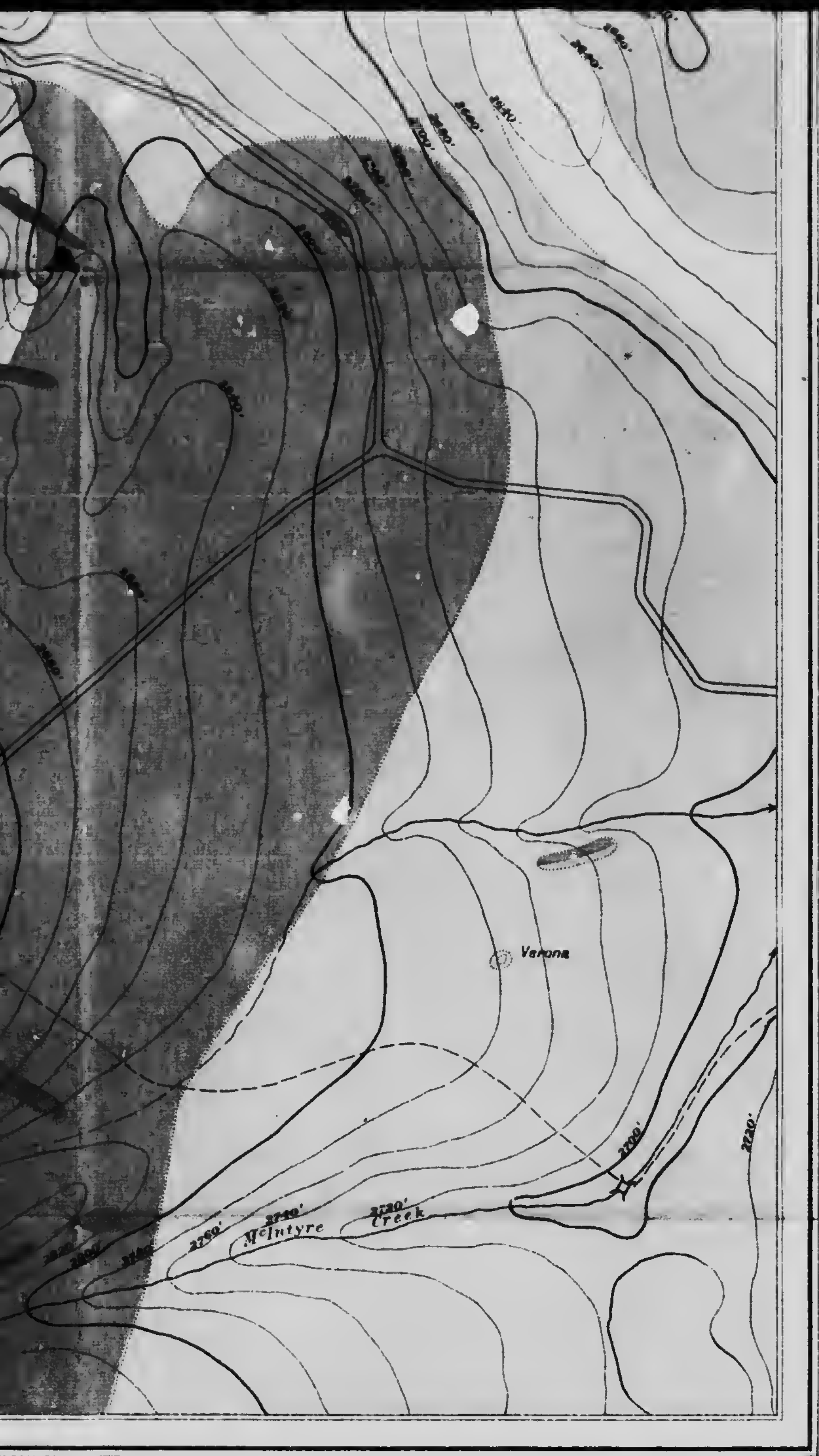
**WHITEHORSE COPP**

**YUKON TERRIT**

To illustrate Repor
R.G. Mc CONNELL, B

Scale 400 feet-1 in

100 50 0 500




*Triangulation points*

*Tunnels*

*Contours, interval 20 feet*

*Elevated tramways*

*Mine dumps*

*Bridges.*

*Contours showing heights above sea-level based on elevation of track at the White Pass and Yukon Railway station, Whitehorse.*

*Magnetic declination about 32°45' East.*

*Topography by* F. H. Maclaren, B.Sc.
*Geology by* R.G. McConnell, B.A.

Topographical
al Portion of
COPPER BELT
RRITORY
Report by
NELL, B.A.

eet=1 inch
1000 1500

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