CANADA
DEPARTMENT OF MINES
HON. W. A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY
W. H. COLLINS, DIRECTOR

Summary Report 1933, Part A

CONTENTS

OTTAWA
J. O. PATENAUDE
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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THE MINING INDUSTRY OF YUKON, 1933, AND NOTES ON THE GEOLOGY OF CARMACKS MAP-AREA

By H. S. Bostock

CONTENTS

INTRODUCTION

With the exception of ten days in August the entire field season of 1933 was devoted to the geological mapping of the Carmacks sheet. The ten days were occupied in a visit to the placers of Klondike and Sixtymile districts.

The writer wishes to express his appreciation of the courtesies and assistance extended to him by all those with whom he came in contact, and in particular by Mr. G. A. Jeckell, Comptroller of Yukon Territory, Mr. E. Holbrook, general manager of the Holbrook Dredging Company, Mr. H. A. R. Stewart of Miller Creek, and the officials of the Yukon Consolidated Gold Corporation.

PLACER MINING

KLONDIKE DISTRICT

During 1933 the Yukon Consolidated Gold Corporation continued to operate its five dredges and some of its hydraulic plant. In Klondike Valley the three large dredges operated on the Boyle Concession. Canadian No. 2, starting approximately a mile below Bear Creek, has been working its way upstream into the central part of the valley. In following this course it has been digging small islands of virgin ground left among the tailings by the old small dredges, chiefly Canadian No. 1. In some of this ground these old dredges are thought to have failed to reach bedrock. It is hoped that some ground that will cover running expenses for this dredge for the next year or so will be found among the old tailings and along their north side. In the meantime it is planned to prove and, if possible, thaw ground on the left limit of the valley below Bear Creek for the future operation of the dredge. A large area of low-grade ground is believed to be present in this section but the regular thawing plant method has proved to be too costly for it. To surmount this difficulty a large part of Klondike River is to be diverted and directed over the ground. This is expected to thaw sufficient of the ground for the dredge to operate on it after two or three years. For this purpose a canal has been begun to divert the water from the river below Bear Creek.

Canadian No. 3 has been working on partly thawed ground in the Bonanza Basin above the mouth of Bonanza Creek. It is dredging a narrow strip along the northeast side of the Bonanza tailings. It is intended to try digging the old tailings of the very first dredging done and some islands of virgin ground, in the course of working down to dredge the site of the old camp of the Yukon Gold Company and ground in that neighbourhood. Canadian No. 4 has been working approximately a mile above Bear Creek and is dredging ground between Klondike River and the left limit of the valley. This is expected to occupy it for nearly two seasons. It will then dig its way up to the mouth of Hunker Creek to dredge some ground that has been recently proved by drilling in that vicinity.

The thawing of the ground ahead of the dredges in Klondike Valley has proved a large item of expense and, therefore, advantage is being taken of every possible means of eliminating this cost. The dredges are being directed to dig as far as possible naturally thawed ground. By this method the thawing operations have been reduced to a great extent, and at present Canadian No. 3 is the only dredge in Klondike Valley with a thawing plant working ahead of it. The hydraulic operations were continued this season on Jackson Gulch and on the Lovett Gulch side of Trail Hill. The Twelvemile ditch, however, is to be abandoned as its maintenance has proved too costly and it is planned to discontinue the hydraulic operations until some future date when equipment will have been designed that will provide a better flow of water. In the meantime dredging operations will be carried out on any dredging ground at the foot of Jackson Gulch on which the hydraulic tailings have been spreading out.

On the Indian River side of the district, Northwest No. 1 continued to dig up the valley of Dominion Creek and is now on Fifteen below Upper Discovery. Sufficient reserves still are present up the creek to keep it in operation there for two or three more years. Ground-sluicing and thawing operations continue ahead of this dredge. Northwest No. 2 is working midway between Granville and the mouth of Sulphur Creek on the right limit of Dominion Creek. Here, too, a thawing plant is necessary ahead of the dredge. A change is being made in this plant by installing pumps to supply a greater volume of water with which to ground-sluice the frozen muck before thawing the gravels below with points instead of thawing the whole thickness of overburden with points. It is expected to reduce the cost of thawing very considerably by this change of method. On Quartz Creek a large stretch of ground is being prospected and prepared for dredging. The prospecting is showing good values and the depth of the gravels is generally close to 16 feet and seldom over 20 feet. In the past a considerable area was cleared and the muck sluiced off in the lower part of Quartz Valley. At the present the brush is being cleared off this area and the remainder of the ground is being prepared for sluicing. It is expected that after the removal of the muck the gravels will thaw to bedrock naturally. A dredge using 5-cubic foot buckets is to be installed. To assist these operations water will be pumped from Indian River. Besides these operations the corporation is carrying out prospecting operations with its drills in many parts of its holdings.

During the season of 1933 the corporation has handled a total of 5,341,194 cubic yards of gravel yielding $571,430.23 in gold, at the value of $1=0·048375 ounce. All the dredges began operating on or before May 16 except Canadian No. 3 which did not start until June 29 on account of the frozen ground. Owing to an unusually early freeze-up in October the dredges were all forced to close down by October 19 which made the season an exceptionally short one, but there were no major stoppages. The average percentage of the season spent on digging for the five dredges was practically 90 per cent.

A considerable number of individual miners and small groups encouraged by the higher value of gold were working during 1933 on the creeks in Klondike district. On Bonanza and Eldorado Creeks there were between twenty and thirty-five men employed in this way. The ground worked lies chiefly on Eldorado, Upper Bonanza, and on the rims below Discovery. Gold Run, Dominion, Sulphur, and Quartz Creeks are also providing employment for a number of men.

SIXTYMILE RIVER

A brief visit was paid to the dredging operation on Sixtymile River and to placers on Miller and Glacier Creeks. This was possible owing to the exceptionally good condition of the road from Dawson to the dredging camp in Sixtymile Valley below Miller Creek. One dredge is operated here by the Holbrook Dredging Company. Directly and indirectly thirty men have been employed by the operation during 1933. The dredge has been greatly improved since it was taken over by the present management and its efficiency much increased. It is run by steam, wood being the fuel. The boiler has a working capacity of 125 horsepower and for the dredge from 6 to 7 cords of wood are burnt per 24 hours. A new bucket line is one of the chief improvements. This consists of a closed line of fifty-two 4-cubic foot buckets instead of the old open line of twenty-eight. The new line weighs approximately the same as the old one but has twice the digging capacity. Another improvement has been the instalment of a modern rubber belt stacker. This dredge will dig to a depth of 20 feet under water. During the writer's visit in August the dredge was being moved up the river to a point just below the mouth of Miller Creek on the left limit of Sixtymile Valley where the ground is more consistently thawed and the areas of pay gravels are better known. The ground in this part of the valley was being stripped of muck to enable it to thaw next spring. Lack of water, however, was a great drawback to the operations during the season. The successful operation of this dredge in a district cut off from hydro-electric power and organized transportation reflects great credit on the management.

A number of individual miners are working along the upper part of Miller Creek and six men, under Mr. H. A. R. Stewart of McCormick, McDonald, and Stewart, on the N.A.T. Concession. On the concession the work is being done on the bench on the left limit of the creek approximately a quarter of a mile up the valley from the Miller Creek roadhouse. This ground proved too deep to hydraulic with the limited amount of water and a tunnel was being driven on bedrock to intersect an area of pay ground known from the findings in some older workings. At the same time some of the shallower ground adjacent to the tunnel was being stripped preparatory for hydraulicking next season. In addition to the operations on Miller Creek six or seven individual miners were working along Glacier Creek and one on Big Gold Creek.

MAYO DISTRICT

This district was not visited during the season and the following notes were obtained from those familiar with the district. Mr. Elmer Middlecoff continued to operate on Highet Creek. Some ten or twelve miners were working on Haggart Creek and Dublin Gulch. Some work was also done on Duncan and Lightning Creeks. There was a considerable increase in activity on the placer creeks about Mayo Lake. Statistics show that 663·92 ounces of gold were turned in at Mayo during the year up to the end of November.

OTHER DISTRICTS

Small placer operations were being carried on in areas widely scattered over the territory.

A few individual miners were reported to be working on Matson, Thistle, and Canadian Creeks and Klines Gulch on Selwyn River.

In the course of the field work on the Carmacks sheet a brief visit was paid to the placers on Nansen and Victoria Creeks. The district immediately surrounding these creeks was examined and mapped in 1914 by Cairnes.[1] At the time of the writer's visit five men were working on Nansen Creek and its tributaries and two on Back Creek, a tributary of Victoria Creek. The miners were working in partnerships of two and individually. For the last twenty years small amounts of gold have been recovered from time to time from these placers in this way.

A miner was reported to have discovered some gold on the North Fork of Big Salmon River.

Some staking was reported to have occurred in the vicinity of Sayea and Scurry Creeks on the west side of Liard River.

In the neighbourhood of Livingstone, one or more individual miners were operating on Little Violet, Lake, Summit, and Livingstone Creeks.

Some placer work was also reported to have been done on Geary Creek, a tributary of Teslin River on the left limit near Boswell River.

A few prospectors were also working on placers in Kluane district.

On Squaw Creek on the Yukon side of the provincial boundary the whole valley within the territory has been taken up in a placer lease and was being tested by the Yukon Ventures, Limited. Mr. John Shaller was directing the work and had four men with him. To date not much gold has been recovered from the Yukon side, but the results of the testing have proved encouraging and it is expected that operation is to be continued in the coming season.

[1] Cairnes, D.D.: Geol. Surv., Canada, Sum. Rept 1914. Nansen and Victoria Creeks, Nisling River, Yukon Territory, Map 151A (Issued 1917).

LODE MINING

MAYO DISTRICT

The writer is indebted to Mr. Livingston Wernecke of the Treadwell Yukon Company, Limited, and Mr. A. K. Schellinger of Keno Hill, Limited, and others connected with the district for the following notes.

The Treadwell Yukon Company, Limited, closed down their mill and camp at Wernecke at the end of 1932 and transferred their activities entirely to their properties on Galena Hill. Here this company mined, sorted, and sacked 3,138 tons of high-grade ore, assaying 492·3 ounces of silver to the ton and 30·6 per cent of lead, from the Elsa group, 600 tons of which are still on hand for shipment in 1934. This exhausted the known reserves of high grade in these workings. In October the activities of the company were transferred to the Silver King group, where mining and sorting continued to the end of the year. On this property, another shaft was sunk for 120 feet to facilitate mining the small amount of high-grade ore available.

Mr. E. Bjonnes continued sorting and sacking on the No Cash mineral claim and shipped 37 tons of high-grade ore.

Very little prospecting has been in progess on Keno and the neighbouring hills during this year.

CARMACKS DISTRICT

Work has been discontinued on McDade Hill, but active prospecting has been in progress on Mount Freegold and the ridge extending to the southeast from it. The geology of this prospecting area is given in Summary Reports 1931, Part A, and 1932, Part A II, accompanied by sketch maps of the topography and general features of the geology. The following notes have been gathered from prospectors working in the locality.

Mr. F. Guder, the original staker in this locality, has been prospecting continuously on the west end of Mount Freegold. He has put in a number of pits and trenches and sunk four shafts ranging between 12 and 23 feet deep. These workings have shown up a number of new veins of mineral and some good gold assays have been obtained.

On the south side of Mount Freegold where it slopes down into Seymour Creek Valley, three groups of claims have been prospected. The northwest group is held by Messrs. Langham, Forrest, and Major, and lies west of the Rambler claim shown on the sketch maps published in the reports of 1931 and 1932. A large number of showings on this group have been uncovered by trenches as well as by an adit. Some of the veins are reported to be persistent and two are reported to have been traced for over 1,000 feet. Their widths vary from 10 inches up to 8 or more feet. A number of very good assays have been obtained from this group and some of the results were published in the Dawson Weekly News, October 6, 1933.

Adjoining this group on the southeast Messrs. G. Fairclough and A. Brown hold five claims and fractions, and several good vein showings have been uncovered here giving some very encouraging assays.

Messrs. J. Carpenter and W. Forbes are reported to have staked some claims approximately a mile farther southeast and to have found a large vein carrying fine pyrite and arsenopyrite and gold values.

GEOLOGY OF CARMACKS MAP-AREA

Though geological work in the Carmacks sheet has not been completed and the following information may be subject to some modification in the light of further field work, it is thought desirable to publish here some general notes on the geology and to indicate their bearing on the selection of favourable ground for prospecting.

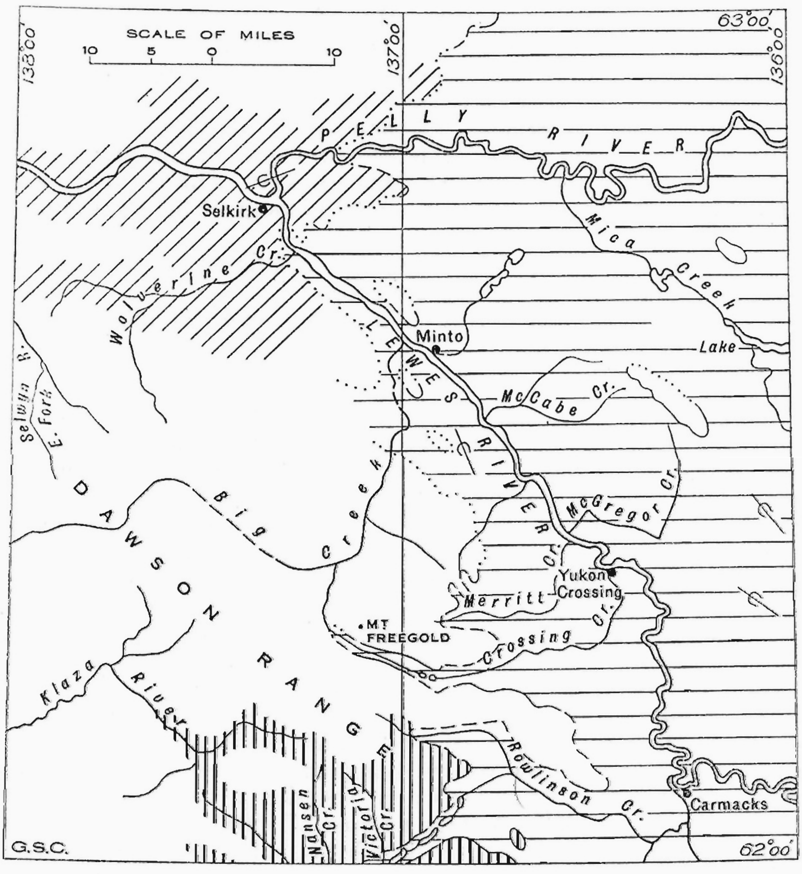

Figure 1. Carmacks area, Yukon, showing area covered by last ice-sheet (horizontal ruling), and areas covered by earlier ice-sheets in the vicinity of Selkirk (diagonal ruling), and of Nansen Creek (vertical ruling).

The district referred to is shown on Figure 1. It embraces the country west of Lewes River and an area between Tatlmain Lake and McGregor Creek on the east side of the river. The district contains large areas of granodiorite and granite and smaller areas of syenite and basic intrusives. All these rocks are thought to be related, but to have formed at intervals during a long batholithic period. The areas occupied by these intrusives are separated by belts of older rocks and by areas of younger volcanic rocks that lie unconformably upon them.

The pre-batholithic rocks include two groups, the Yukon group, thought to be mainly Precambrian, and the Older Volcanic group, probably of Mesozoic age. The Yukon group within the district consists of schists, gneisses, quartzites, and limestones. These rocks are well stratified as a rule. Schists varying from nearly pure quartzites to biotite schists form the greater part of the group, though schists and gneisses containing variable quantities of hornblende, feldspar, and quartz also form a large part.

The rocks of the Older Volcanic group along Lewes River are mainly green, basaltic lavas but minor areas are occupied by andesitic volcanics, diorites, and tuffs. In the Dawson Range, porphyritic andesite of greyer green colours predominates and tuffaceous members are more abundant. This group unconformably overlies the Yukon group.

The batholithic intrusives may be divided into three groups, namely, a syenite group, a granodiorite and granite group, and a group of rhyolite and granite porphyry. The rocks of the first-mentioned group form a number of small stocks and bosses following a northwest-trending belt in Dawson Range. They include many varieties of syenite, porphyritic syenite, and hornblende syenite, and show phases grading towards granite. When relationships could be found these syenites are intruded by the granodiorite and granite. With the syenites are grouped small bodies of diorite and gabbro considered as probably belonging to the earlier phases of the batholithic intrusion.

The granodiorite and granite of the second group compose very large bodies. They include both coarse porphyritic types and medium-grained types, and in places along their contacts they pass into massive, foliated varieties.

The rocks of the third group form numerous bodies, mostly small, of rhyolite, granite porphyry, and felsite types. They occur along Dawson Range and scattered over the areas on either side of it. Most of them occur near the borders of the bodies of granodiorite and granite and they cut these rocks.

The Newer Volcanics are divided into the Carmacks volcanics and the Selkirk volcanics. The Carmacks volcanics are chiefly basaltic and andesitic lavas and breccias, but include in some places trachyte and other volcanic types. In a few places shale, sandstone, and conglomerate underlie the volcanics and are exposed at the borders of the areas of these volcanics. The Carmacks volcanics have suffered warping and faulting and were once much more extensive. The Selkirk volcanics consist of black, basaltic lavas and tuffs which in Pleistocene and Recent time were poured out into the valleys in the vicinity of Selkirk and west of McCabe Creek. The areas of Newer Volcanic rocks are regarded as unfavourable for the occurrence of lode deposits, but the remainder of the country presents possibilities as over it the strata are invaded and underlain by great bodies of intrusive rocks. A belt of country that extends from the heads of Victoria and Merritt Creeks northwestward to the head of the east fork of Selwyn River is thought to offer more promise than the rest. Within this belt areas of the rocks of the Yukon and Older Volcanic groups are intruded by bodies of syenite, rhyolite, and granite porphyry, and the whole is bordered on both sides by large areas of granodiorite and granite. In the southeast part of the belt occur the prospects in the vicinity of Mount Freegold and the placers of Nansen Creek district, and in the northwest placers have been found on Selwyn River and its tributaries. The areas of rocks of the Yukon group lying outside the belt are also promising, for none of these areas is remote from intrusives.

Since it is within this belt of country that geological conditions seem to be most favourable for the occurrence of lode deposits, it follows that this particular area may hold the original sources of the gold of placers and, therefore, is worthy of being prospected for placer deposits. It is of interest to note that those tributaries of Nansen and Victoria Creeks on which placer gold has been found drain at their heads areas of rhyolites and granite porphyries, but it should be remembered that the important placer discoveries in Yukon occur in areas of rocks of the Yukon group.

Parts of the district have been subjected to more than one period of glaciation (Figure 1) and this important factor should be considered in searching for placers. The features of the last glaciation are still fresh and unmodified and show that in the area covered by the last ice-sheet placers probably have not formed since the retreat of the ice. The area occupied by the last ice-sheet is unfavourable ground for prospecting for placers, not only because of a lack of recent placers there but because any earlier formed placers probably will either have been largely or completely destroyed by the disruptive actions of the ice-sheet or have been buried by the later glacial deposits.

The western limit of the last ice-sheet has not been fully determined. Its position as indicated by the available evidence is indicated on Figure 1. Glacial deposits in the vicinity of Selkirk that lie west of the border of the last ice-sheet present evidence of being older. They have been much modified and partly destroyed.

The Nansen and Victoria Creek placers lie outside the area occupied by the last ice-sheet. Cairnes[1] in his report on Nansen district mentions the finding of boulder clay in some of the placer workings. It was found this year (1933) that this boulder clay holds completely rotted pebbles and is buried under more recent deposits formed by normal erosive agents. Where the boulder clay was seen, the paystreak rests on it and it is reported that no paystreak occurs on bedrock beneath the boulder clay. The boulder clay in Nansen Creek district is thought to be older than the glacial deposits of Selkirk district because in Nansen Creek area all evidence of glaciation, except that presented by the boulder clay, has been destroyed. The placers of Nansen district formed in a long period of normal erosion following the disappearance of the early ice-sheet. The extent of this early ice-sheet is unknown. Areas believed to have been covered by it are represented on Figure 1. These areas are indicated by the high elevation of the occurrences of boulder clay and by drainage features.

1 Cairnes, D.D.: Geol. Surv., Canada, Sum. Rept. 1914.

MANSON RIVER AND SLATE CREEK PLACER DEPOSITS, OMINECA DISTRICT, BRITISH COLUMBIA

By F. A. Kerr

CONTENTS

INTRODUCTION

In 1932 the Geological Survey commenced the mapping of the part of Omineca district between the Finlay-Parsnip Rivers Valley and the Takla-Driftwood waterway, and extending northward from Nation River. Topographical mapping was carried on during 1932 and 1933 by A. C. Tuttle. In 1933 geological work was commenced by the writer with the assistance of C. O. Hage.

The southern limit of the area lies approximately 100 miles north of the northern route of the Canadian National Railway in central British Columbia. Access to the area is gained by three routes. To the eastern part of the area travel is usually by boat along the Parsnip and Finlay River systems from Summit Lake, which can be reached by an automobile road about 40 miles long from Prince George on the railway. The other two routes start from Fort St. James, about 40 miles by fairly good road from Vanderhoof on the railway. Travel to the western part of the area is mainly by boat along Stuart Lake and a series of waterways to Takla Lake and Driftwood River. To the central part of the area there is a good pack trail. The journey to Nation River, a distance of about 75 miles, can be accomplished in three or four days, and to Slate Creek (about 125 miles), in about the centre of the southern section, in about seven days. The trail has been considerably improved in recent years and during the dry season of about three months in the summer and again just after freeze-up in the autumn is suitable for travel by car. Cars have gone about 100 miles. Beyond this two routes—one for summer and one for winter—have been slashed out and improved sufficiently that wagons can get through in summer and sleighs and tractors in winter. Small quantities of easily handled materials can be taken into Slate Creek for about 5 cents a pound during the season when the snow is off the ground. Airplane transportation to Slate Creek via Germansen Lake, about 8 miles away, has proved to be very satisfactory. For the northern part of the district, away from the two water routes, air transportation would seem to be the most satisfactory, but must be combined with the use of pack horses since there are not sufficient lakes suitable for landing to make more than a relatively small part of the total area readily reachable by plane.

The southern part of the district is fairly well traversed by trails and the open character of the country makes it possible to reach almost any section with horses without serious difficulty. Northwestward beyond Omineca River, trails are not so numerous and the country is more rugged and travel much more difficult. Along the valleys and in the lower areas there are usually small meadows that afford good feed for horses between the middle of June and September. In some years, such as 1933, feed is not good before July, but in others it may become so early in June. Above timber-line on the less rugged mountains there is usually good feed for two months or more during the summer.

The district has in general a fairly favourable climate for working. In some years, such as 1932, the summers are mainly fairly wet and disagreeable, but in others, like 1933, the weather is very good. However, in 1933 snow was still abundant above timber-line well on into July. There was a heavy snowfall early in September and after the middle of the month there was usually a mantle of snow on the mountains, and before the end of October there was a heavy accumulation everywhere, though a later thaw removed much of this. For prospecting the season is short, though placer miners have continued working to as late as Christmas day, which of course is very exceptional. Likewise, work along the valleys can be commenced fairly early providing supplies are available.

Game and fish are not plentiful in the southern part of the district and cannot be depended upon to supplement supplies.

The district was visited by R. G. McConnell in 1895. He traversed Finlay and Parsnip Rivers. In 1915 Charles Camsell made a rapid reconnaissance survey along the western waterways route to Takla Landing, thence by trail to Slate Creek and back to Fort St. James. In 1927 Victor Dolmage traversed Finlay River and some other sections to the west, and compiled a map and report that were published in the Summary Report of the Geological Survey (Part A) for 1927. This report provides a good summary of the general knowledge of the district. The British Columbia Department of Lands has published a general map of the district and there is much valuable data on placer and lode gold deposits in the annual reports and other publications of the B.C. Minister of Mines.

Between the Canadian National Railway and Nation River there is an extensive area which is mainly relatively flat with a few isolated mountains and groups of hills rising above the general level. The river valleys are not deeply cut and in the main the relief is small. Northward to the vicinity of Nation River and beyond there is a general increase in ruggedness. Low, relatively flat areas become more limited in extent and mountains and mountain groups become more numerous, higher, and more rugged. Eventually, low areas are only the great valleys cut out by the present rivers and by ancient rivers or glaciers. These traverse mountainous country, but in general the mountains are among the least rugged in British Columbia. The valleys fall into two series: those that trend northeast and are occupied mainly by the rivers that flow to the Parsnip and Finlay; and another series of valleys that are just as large though not always as continuous, and trend northwest and southeast.

In the part of the district between Nation and Omineca Rivers with which the present report is mainly concerned, many mountains rise above 6,000 feet. The higher peaks generally occur in groups or ranges that tend most commonly to have a linear direction northwest and southeast. The most pronounced range is the Wolverine which follows along the west side of the great Rocky Mountain trench.

Between the ranges and mountain groups in this section there are large valleys, and in places extensive, low-lying areas broken by hills and valleys, thus presenting a relatively gently undulating surface. The valleys because of the canyon-like character of many of the stream channels give to these parts a certain degree of ruggedness.

This part of the district presents many features inherited from the last ice age. Old, abandoned or largely abandoned channels are common and are to be found from the higher gaps in the mountain ranges down to the lowest valleys. Lateral and terminal moraines are numerous. Old beaches, delta deposits, and lake bottom deposits are common. All these features, products of the retreat of the last ice-sheet, have been remarkably well preserved because there has been very little alpine glaciation and the relatively mature character of the topography and the climatic conditions do not lend themselves to the rapid erosion.

GENERAL GEOLOGY

What appear to be the oldest rocks within the area examined in 1933 are confined to Wolverine Mountains. They form a belt that is a southeasterly continuation of the band of so-called Precambrian represented on maps as crossing Omineca River above the mouth of Osilinka River. The rocks in the Wolverine Mountains are banded and, though greatly metamorphosed, the banding may correspond to original bedding. In the western part of the range the rock structures dip fairly uniformly to the southwest. The rocks are mainly quartz-feldspar gneisses, mica schists, and quartzites. The middle part of the belt (it lies along the axis of the mountain range) is mainly composed of gneiss cut by an abundance of pegmatite dykes and aplitic masses. The gneisses and schist grade to pegmatitic material, and also occur in sharp contact with pegmatite bodies. In some places whole cliffs are made up of interlacing, aplitic and (or) pegmatitic masses which have the greatest irregularity in shape and size. They are in the main tabular and commonly occur parallel to the banding. In the central part of the range one mountain may be largely of these materials and others may be comparatively free from it. All the masses are small, probably few are over 100 feet thick and perhaps none exceeds 200 feet.

Beyond this central core on both sides of the range there are bands of rock in which quartz-mica schists predominate. These are most commonly dark grey biotite schists and they differ from the gneisses in the presence of a much greater amount of biotite. There are also muscovite schists. Mica plates of 1 to 2 inches in cross-section are common, and garnet crystals up to 1 inch in diameter are abundant in places. The schist series contains gneisses and quartzites and differs from the gneiss series only in the relative quantity of the various types of materials. The flanking schists grade into the central body of gneisses, but, nevertheless, the boundaries between the adjoining belts are moderately well defined. Pegmatites occur with the crystalline schists and show the same relationships as those in the gneiss series, but are generally much smaller and much less abundant. The flanking schists seem like less metamorphosed phases of the same rocks that were transformed to gneisses.

The belt of crystalline schists and gneisses is flanked on the west, along the western edge of Wolverine Mountains, by a belt largely made up of phyllite, slate, and quartzite. Some of the schists were originally fine conglomerate in which, under favourable conditions, the pebbles can be recognized. Toward the eastern edge of this band there is an increase in the number of coarse crystals of biotite and other minerals, and the rocks tend to become much like the schists and gneisses to the east, but although there is somewhat of a gradation from one series to the other, yet the gradation is fairly rapid.

The division between the two rock groups is not much more marked than that between the two subdivisions of the schist-gneiss group, and it may be that the differences are due to metamorphism and do not indicate differences of age. McConnell assigned the schist-gneiss group to the Precambrian and the less metamorphosed, apparently overlying strata to the Cambrian.

Along the western flank of the Wolverine Range, overlying the series just described, is a formation of crystalline, and in places schistose, limestones. These rocks where observed by McConnell on Omineca River form a wide band. Isolated masses of similar limestone appear to be infolded with older rocks, and in other places occur with younger rocks, and there appear to be on the crests of anticlines.

In the vicinity of the placer-producing area of Slate Creek and Manson River, to the north along the Wolverine Range, and elsewhere, there are extensive exposures of dark grey and green and black slate and phyllite with, in minor amounts, bands of limestone, dolomite, and quartzite. Other rocks such as volcanics may belong to this series. Its age is unknown but possibly is Palæozoic. Prospectors claim that the placer gold deposits are found only over this slate series and that the gold deposits from which the placer gold was derived must lie within it. Quartz veins and masses are fairly common in many places.

On a mountain lying north of Manson River and west of the Wolverine Lakes, at the base of Wolverine Mountains, there was observed a series of schistose, altered, volcanic rocks with some interbedded sediments. The relationships of this assemblage were not established. They may be related to the slate series.

Throughout much of the area studied there are bodies of massive green volcanics which show no metamorphism comparable with that exhibited by the rocks described above. South of Omineca River they occur mainly in isolated masses. North of the river and in the vicinity of Germansen Lake and eastward toward Slate Creek there are extensive areas of these rocks. Where examined they exhibit few traces of bedding and are dominantly dark green, but in places are grey or red. Rarely the rocks are bedded like tuffs and in places there are cherts, jasper, and argillites. These rocks in places are cut by fairly numerous quartz veins, especially near the contact with the older slate series. The volcanic series is presumed to be of Triassic or Jurassic age.

South of Germansen Lake a series of argillites, slates, and quartzites underlies the a series of volcanics. The sediments are somewhat less metamorphosed than the sediments found to the east, and in general aspect most resemble those of early Mesozoic age found in other parts of northern British Columbia.

The youngest rocks are of granitic types and form an intrusive mass lying south of Omineca River. Its northern limit is a very short distance south of Germansen Lake. Its western boundary is south of the middle of Germansen Lake and extends southward for many miles. The mass trends southeast and underlies much of the Germansen Mountains, the basin of the South Fork of Germansen River, and Bald Mountain. It crosses the Slate Creek trail and extends southeast to Mount Milligan, over a total length of more than 40 miles. The rock in the main appears to be fairly uniform in composition and of fairly coarse texture. It has sharp contacts and few if any dykes or pegmatitic bodies are associated with it. Certainly there is nothing to suggest that it is in any way related to the pegmatites found with the gneisses and schists of the Wolverine Range.

None of the important lode deposits of the section traversed were studied. During the progress of the work, however, abundant evidence of mineralization was observed.

Quartz veins carrying small quantities of pyrite, chalcopyrite, galena, sphalerite, tourmaline, and other minerals were observed in an area that lies west of and includes the Wolverine-Manson Valley from above the upper lake on Manson River to Omineca River. Most of the veins are of quartz or quartz and pyrite. Samples of some of the veins were collected and assayed, but none yielded appreciable percentages of gold or silver.

PLACER DEPOSITS

Placer gold was discovered on Pete Toy's bar on the Finlay in 1861, seven years later far to the west on Silver Creek, in 1869 on Vital, in 1870 on Germansen, and in 1871 on Manson. Production has been mainly from the last three, from Tom Creek, and four tributaries of Manson, Slate, Lost, Black Jack, and Kildare. The Manson area was probably the most productive. Activity has been continued in the district with some production every year since discovery. McConnell states that for the first few years after discovery the bars proved exceedingly productive and probably had their best yield. Unfortunately, no record of production is available until 1874 when the yield had already begun to fall off. The succeeding three years saw little activity, but thereafter activity increased until 1880 when eighty miners well distributed on the various creeks recovered $45,000. From then to 1897 there was a gradual dwindling to another low period. Up to this time McConnell estimated a total production of $1,000,000 for the district, about half of which would have been secured prior to 1874. From 1897 on there followed the entry of many companies with much capital. Large expenditures for machinery were incurred and a number of long, costly water systems were constructed. One company in a few years spent $250,000, and it is likely that during a period of about seven years the money expended was more than the value of all the gold recovered to date. During this period the annual production averaged only about $20,000.

Following this period of activity there was a slight decline in production until 1908 when, and, for four succeeding years, renewed interest was displayed in the district. Since then, and until recently, activity was at a low ebb and the annual production dwindled to between $3,000 and $5,000. The last few years has again seen the revival of interest on the part of companies. In 1933 three companies possessed equipment capable of handling comparatively large quantities of gravel.

On Germansen Creek the Germansen Placers, Limited, has installed over 6 miles of ditch and flume to supply water for hydraulicking. Operations were carried on throughout the last season. On Slate Creek the Consolidated Mining and Smelting Company has almost completed the installation of equipment for the operation of a 2-cubic yard, Sauerman high-line scraper. On Manson River the Omineca Placers, Limited, early in the summer of 1933 began operating a 1-cubic yard, high-line scraper. Besides these three operations, miners have been working at several other places on Manson River and its tributaries and on Germansen Creek. On Vital Creek a number of Chinamen have been drift-mining for several years with, it is reported, consistently good returns. Elsewhere on Vital and Tom Creeks other operations, as yet not very productive, were being carried on.

In the Germansen-Manson area in the sixty-two or more years that prospectors have been frequenting this area, most of the old channels and rock benches along the deeply cut valleys have apparently been discovered and tested. Throughout the area there are scattered hundreds of test pits and adits, and it is clear that practically all readily discernible possibilities have been investigated. Some of the prospectors had a remarkable fund of knowledge gained by the experience of many years. Very little of the information that had been gained by their work is now available, but much of the same knowledge has been obtained from a study of the geology and is given here. The chief efforts of the present undertaking were directed toward acquiring information that might direct further search along lines likely to be profitable. Work was almost entirely confined to the area shown in Figure 2, but is not complete because the relationships of features beyond the area, and which have an important bearing on those within it, are not yet known. The following detailed descriptions of workings refer only to the area shown in Figure 2.

On Manson River there is no evidence of extensive workings above the canyon situated 2,000 feet west of Kildare Creek. Published reports and statements by prospectors are in general agreement that no gold has been found on Upper Manson River except on Sawmill Creek, a tributary from the south, where some gold may have been secured. One report is to the effect that the miners made $6 a day, but that there was no bottom.

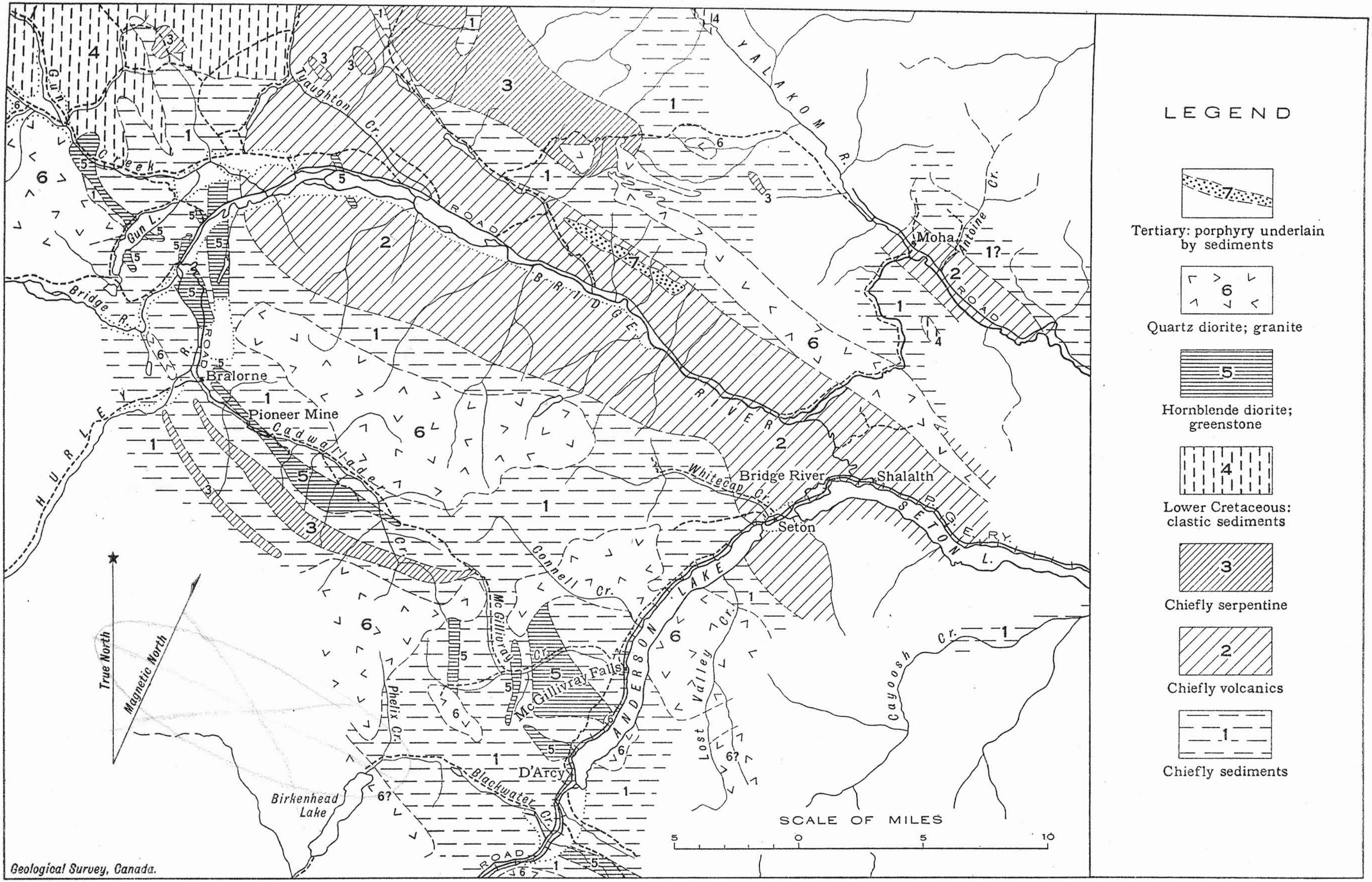

Figure 5. Geological sketch of Lillooet area, Lillooet district, British Columbia.

On the north side of Manson River, for a short distance above the canyon west of Kildare Creek, and for 600 feet below this point, there is evidence of much testing of old channels and the bed of the creek. Below the canyon on the south side of the stream an extensive bench lies slightly above the river flats. Bedrock is close to the surface over much and perhaps all of the bench. There is a considerable area of workings along the edge of this bench near the river, but the ground has been completely worked over a small part only of this, and it is believed from the appearance of the workings and from reports that pay in general was not good, though in places wages may have been made. Prospectors report fair pay on the rock bench, but none in the creek. The flat south of these workings has been extensively tested by pits and it appears probable that it did not show much pay. Adits at the bend below this flat are numerous, but do not appear to have yielded much. A large flat below this, which is probably largely underlain at little depth by bedrock, has been extensively worked and much of it probably paid well. Adits into the south bank also are reported to have been profitable to some extent.

On the north side of the river the large flat extending across the mouth of Kildare Gulch is fairly well covered with workings. The ground was mainly reasonably shallow and probably paid well. In 1933 workings on this flat, in ground left by the old timers, paid at least good wages. The early miners did not extend their workings up Kildare Gulch, but a company operated an hydraulic lift there. They stripped 2,665 cubic yards, excavated 4,088 cubic yards, and cleaned 15,625 square feet of bedrock to recover about $1,200. The ground, therefore, was not good pay. Conditions and pay were said to be improving up Kildare Creek, but the fact that the company shifted their apparatus to another site does not appear to indicate that prospects were at all bright. It would appear, therefore, that the best pay does not continue up Kildare Gulch.

Two benches below the lake that lies south of Kildare Gulch probably paid fairly well, probably as the result of favourable conditions. Prospectors report that good pay was secured on the "rim" only. Workings farther up the gulch were more spotty. The old channel from Manson River to Kildare Creek in which the lake lies and the rock bench along the west side of it have been tested, but apparently did not show much gold. Lower Kildare Gulch has been tested in a number of places. Rock benches occur along its sides and in places bedrock outcrops close to the stream. There is no evidence of appreciable values having been found. Old adits enter the west bank for some distance above the mouth of the creek, but do not appear to have encountered pay ground nor to have offered good prospects.

Black Jack Creek near its mouth lies in a rock canyon. The whole length of the canyon is vaguely reported to have been worked with fair results two or three times, but there may have been confusion in this report with workings higher up. Above the rock canyon the stream is confined to a canyon for a length of about 2,000 feet. Along this section workings form a narrow, continuous band which weaves a course in and out of the present channel and appears to indicate the position of a continuous paystreak which probably paid well. On the east side where there appears to be another old channel some old adits are observable, but are not thought to have been very productive. The main paystreak at its lower end crosses to the west side of the stream channel and from that point a big gap, cleaned out by hydraulicking, extends down to Manson River. It is said that the ground was tunnelled before hydraulicking. According to the reports by the Gold Commissioner, hydraulicking was carried on throughout the season of 1901 when the recovery for the whole district was only $19,000, the larger part of which undoubtedly came from elsewhere. Twenty days in 1902 yielded $3,760 and in 1903 ten men operating to July 6 recovered $2,700. No mention of further operations is made. The ground between the head of the hydraulic pit and Black Jack stream channel was exposed in 1933 and showed evidence of much tunnelling from the Black Jack side. Over parts of the area decomposed bedrock is visible, the rock surface pitching to the southwest. These parts were being worked by one man. The old channel seems to cross the head of the hydraulic pit and appears to reach Manson River at the bend a short distance above the hydraulic pit. At the bend of the river there is evidence of old adits and it is said that these followed up the old channel to meet those driven from the present Black Jack channel.

It is reported that some adits in the north bank of Manson River below the mouth of Kildare Creek paid well.

On the south side of Manson River, below Black Jack Creek, there is a rock bench lying between the present stream and a depression that may mark an old channel. The lower end of the rock bench has been thoroughly worked and, according to a prospector who worked there, yielded over $100 per man a day for a short period. The upper part of this bench has been tested and worked in places, but the work does not appear to have yielded much in the way of returns. North of the river, from a point a short distance below a point opposite the mouth of Black Jack Creek, a series of adits continue, with some interruptions, downstream to Discovery Bar. Most of the adits are very old and information about the extent of the ground worked and the nature of the paystreak is only vaguely known. The large number of adits, the extensive tailing piles, and other features indicate that in some places much ground was worked and that probably very good values were obtained. The richest sections are believed to have been those in the bends above and below where a trail strikes the river opposite a small creek. Prospectors report that in the lower section work from one adit alone was continued for nearly twenty years. All the adits were driven on top of bedrock, and in the two examined the bedrock surface is nearly flat. Near Discovery Bar the nature of the workings suggests that the ground was less favourable. The great water supply brought by the flume and ditch from upper Manson River was turned on the high bank above and opposite Discovery Bar and a large quantity of dirt was washed out, but the returns were low.

Reports are at variance as to the extent and value of workings in the main channel of Manson River; some say it has all been worked out at least once; another report is that it did not pay well except at Poverty Bar. The gold commissioner reports that the Evans claim, comprising 300 feet of the bed of the stream ½ mile below Kildare Creek, paid well. There is clear evidence of workings at Poverty Bar, in the stretch above Discovery

Bar, and at a few other places. It is reported that practically all the workings along Manson River, whether in the present channel or above it, went to bedrock or were on bedrock.

A number of old adits are visible along the southerly trending bank east of the river above Discovery Bar. These are reported to have yielded no pay.

The rock bench at Discovery Bar has been extensively worked and probably, as reported, paid well. However, some sections of the ground were not worked, which suggests that these parts at least did not show good values.

Some adits were driven in the east bank of the river about opposite the centre of Discovery Bar, and it is reported that some adits in this bank struck rich ground.

The easterly trending part of the western river bank opposite Discovery Bar sloughs away continually so that any old workings may have been destroyed. However, it is believed that there were none. Along the west side of the river from the sharp bend below Discovery Bar, to and across the old channel followed by the trail, there are a number of pits and adits but nothing to suggest that the tests here were encouraging. Within the old channel, which reaches Manson River about 400 feet lower down, are similar test pits and apparently there, too, no encouraging values were found.

On the south side of Manson River, below the canyon below Discovery Bar, there is a low flat of considerable area which shows evidence of having been tested. Little other work seems to have been done on it. East of the flat and lying above it, there is a narrow rock bench that has been fairly well worked. Along the terrace that continues down stream beyond where the rock is close to the surface there has been considerable mining at various periods, but it is believed pay was poor and that the chief reason the rock bench up river was worked was that the ground was shallow.

Farther down river there is, on the east side, a lower rock bench known as Mosquito Bar. Sections of this have been throughly worked, but much ground has not been worked at all. Workings extend up Mosquito Creek, but of these possibly only those near the mouth of the creek paid well.

A few test pits were noted on the upper part of Slate Creek, but no other evidence of workings.

A considerable part of the south bank extending upstream from the crossing of the old Modie trail has been ground-sluiced by water from a ditch along the hill-side. The ground does not appear to have paid well, though one report is to the effect that it did but that there was difficulty with the water supply. On the south side below the trail crossing there is a long rock bench that ends or passes under the drift bank downstream. The lower end has been extensively worked, and apparently paid well. Towards the upper end the workings decrease and finally are represented by test pits only, as if indicating that the ground became poorer.

Farther down stream on the south bank, just above and below the dam, there are discontinuous workings. These continue downstream to a rock bench which has been fairly well worked. Eastward the rock surface appears to be lower and the workings die away.

Attempts have been made to mine the bed of Slate Creek at three places between the dam and the road crossing. The middle working is described in the Gold Commissioner's report for 1901. It was 75 feet long, 40 feet wide, and 30 feet deep. Pay dirt extended from 2 or 3 feet below the surface to the bottom of the pit. Bedrock was found along the north side of the pit, the rock surface sloped to the south. The material excavated held a high percentage of boulders about 1 foot in diameter, with some measuring 4 feet. The ground is described as having been exceptionally rich and as having yielded $14,000. Prospectors say that the upper hole was 32 feet deep and the total yield small, being only $700. The lower hole, which is situated near the road crossing, is said to have yielded $3,200.

On the south side of Slate Creek, below the large flat, there is a small area of workings. Prospectors say that the small area paid well but that the overburden became too deep. On the north side of the stream there is a high rock bench. The whole of the upstream part of this seems to have been thoroughly worked. Downstream the workings decrease in number and size and the ground apparently was found to be poorer; test pits continue for some distance beyond the workings. The old channel here, occupied by a small stream that comes from the north, has been tested, but probably this did not offer encouragement.

Some distance downstream there is an area of workings on the north side which are reported to have afforded good pay, but the ground was difficult to handle. On the south side, opposite to these workings, is another area that may have been worked. These two areas appear to be in an old channel that crosses Slate Creek here.

At the big bend in Slate Creek, near the second road junction, a considerable amount of tailings lies in the valley bottom. On the north side of the creek considerable work has been done across what appears to be an old channel. There may have been drifts going north along this, but other than a certain amount of sloughing of the hill-side there is no definite evidence to indicate this. In the valley flat opposite several holes have been dug. On the south side of the valley there is some slight evidence of workings. Apparently there was some good gravel in this section and it is reported that the old channel on the north side paid well.

About 600 feet below the rock junction a considerable area of the valley floor is covered with a thickness of several feet of tailings. Remains of old adits are visible along the west bank. It is reported that an old channel along here was extensively worked and paid well. Farther down stream workings along the west side continue for a considerable distance. In places these appear to have paid well, but elsewhere the results do not seem to have warranted working all the ground, though it was extensively tested. Lower down stream is a small area of workings on the east side of the creek.

Besides the test pits already noted there are many others at widely scattered points. Some are where there appears to be no well-defined reason for their location. Terraces north of the junction of Kildare Creek and Manson River are reported to have been extensively tested and to have shown some, but generally low, values in most places.

Within the area studied there has been very little alpine glaciation: only on the higher mountains and in the larger valley were there local glaciers of any size during the Pleistocene. Even the largest of these did not, as a general rule, extend beyond the mountains where they developed, for instance few if any glaciers on Wolverine Mountains reached the great valleys that lie along their base. Glaciation by the main ice-sheets, therefore, is the chief consideration.

The area was completely covered by one or more ice-sheets. In places there are two or even three till sheets separated by sands and gravels, and this suggests that there were glacial and interglacial stages. Evidence gathered throughout the district visited indicates that the main movement of the last ice-sheet was southward. The direction of transport of boulders by the ice clearly indicates this. There were, of course, minor deflexions from the general direction, especially at late and early stages of advance and retreat of the last ice-sheet. Parts of the main ice-sheet may have tended to follow valleys wherever this was possible, and to move around hills and mountains.

The southward moving ice tended to erode deeply all valleys that had a direction trending between northwest-southeast and northeast-southwest. Valleys trending in other directions were much less affected, and in many cases their floors may not have been eroded; on the contrary, there was a tendency for them to become filled with drift. In some cases tributary valleys, such as Black Jack, leading into a major east-west valley, even though they possessed a north-south direction, might have been protected from erosion as a result of the influence exerted by the major valleys. Hills such as those between Kildare and Slate Creeks and those north of the latter were eroded on their north sides, but on their south sides drift tended to accumulate, thus protecting the valleys to the south.

As a result of ice erosion many valleys were robbed of any placer deposits they may have held in pre-Glacial time. North-south valleys, especially those that are moderately wide and U-shaped, are most likely to have been affected by ice erosion. In the lower parts of the area, where there is a deep drift filling, channels trending in any direction may have been preserved because of the protection from ice erosion afforded by the hills to the north and south.

In places the ice may have disturbed the ancient placers and mixed them with the glacial drift, but so that the gold remained nearly in its original position or was transported for a short distance only. The process of mixing with drift would, in all cases, render the placers less valuable. In places, however, reconcentration by an interglacial or late glacial stream may have formed rich deposits out of some of the shifted material.

That the last ice-sheet melted back towards the north is shown by the east-west trend of the recessional moraines. When the ice was melting back the drainage was diverted to the east, and as the south sides of valleys were uncovered first, channels tended to be developed along these sides. Thus Manson Channel now is cut in the south side of the rock valley, as is shown by the much higher rock wall to the south than to the north. Old channels, therefore, in this and other similar valleys are most likely to occur to the north of the present channel.

Ice erosion and deposition of morainic material greatly changed the configuration of the surface. Some parts were reduced by erosion, and over others the surface was raised by drift filling. The features now preserved show that when the ice was retreating there were few, deep, V-shaped channels in existence. The hundreds of channels now visible on the surface of the drift were cut in the main during the retreat of the ice. Their great number is due to the development of a new drainage system for each successive stage of retreat of the ice. A study of many of the channels of the area shows clearly that they begin on a slope which could not possibly be a source of water unless ice covered the slope below and acted as a dam so that the drainage water flowed along the slope. As the ice advanced over the area several times other channel systems were developed. Parts of these have been preserved, so that there is now a complexity of buried channels.

The only places where important placers have so far been found is along stream channels cut partly in the drift and partly in the bedrock. All the old workings are on or near bedrock and are not far above the levels of the streams along which they occur. Much testing of higher ground has been done during the many years of placer mining, but with little or no reward.

In considering the occurrences of gold two main alternatives present themselves: was the gold brought into the area as part of the glacial drift and concentrated by stream erosion of the drift, or was it present along old channels within the area where it had been concentrated during some interglacial period or prior to glaciation? If the placer gold has been derived from the glacial drift it would be expected that in general the amount of gold in any channel would be proportionate to the amount of drift eroded during the formation of the channel, and that gold would be found in all channels that have been cut deeply in drift. The evidence, however, shows that this is not the case. There are parts of Manson, Kildare, and Slate Valleys where hundreds of feet of drift have been washed out by the streams without any appreciable concentration of gold. The washing by mining companies of great thicknesses of the drift was relatively unproductive. The spotty distribution and the varying richness of deposits bear no apparent relationship to the amount of drift that has been washed. Furthermore, each stream is known to have a slightly different type of gold which would hardly be the case if the placer gold had been part of the glacial drift. All these features tend to show that the gold in the main was not brought into the area with the drift that now deeply overlies much of the rock surface.

Apparently before the heavy mantle of drift accumulated—or at least before most of it did—the gold must have been concentrated in the areas where it is now found. Many of the deposits that have been worked were overlain by deep drift, and it is reasonably certain that practically all were deeply buried until again exposed as a result of the erosive action of the streams. During the last sixty years the search for placer gold has been so intensive along the deeply cut channels of the present streams that the chances of finding any more important deposits are not encouraging unless there be some deep ground that could not be profitably worked by the methods heretofore employed. The chief hope of new discoveries, therefore, lies in finding buried deposits not clearly disclosed along the present stream channels. Such deposits will, of course, most likely be in old stream channels.

Since practically all the gold deposits occur on or near bedrock it is chiefly channels cut in the rock that are of interest. Such buried rock channels are not identifiable by the contour of the surface of the drift. The old channels and the higher rock surfaces on their sides may be overlain by hundreds of feet of drift, and depressions in the bedrock surface may be overlain by hills of drift. Unless the slope of the present land surface is steep and bedrock is not far below, the present surface affords little or no evidence of the positions of channels in the bedrock.

In the present valleys of Manson River, Slate and other creeks there are indications of many buried ancient channels. Where the rock walls of the present channels are steep and the drift covering is thin, the presence of ancient channels is readily recognized by the occurrence of V- or U-shaped depressions in the rock surface below the drift filling. Unfortunately, however, owing to the heavy covering of drift in most places and the sloughing of the drift down over the rock sides of the valleys, most buried channels are difficult to locate.

A number of criteria are of considerable assistance in attempting to locate ancient buried channels. Any considerable decrease in the elevation of, or the disappearance of, a rock wall suggests that a buried channel may occur. In many such places, however, an abundance of materials derived from the bedrock, and occurring at the surface or a few inches below it, indicates that bedrock is not, after all, far below and that it has merely been obscured by sloughing of drift from above. An abrupt widening of the present channel generally marks the junction with an ancient buried channel. Marked embayments in the wall of a present stream channel and sharp beds in their course may indicate the positions of ancient channels, many of which follow nearly the same courses as the present streams. The presence of old workings is, of course, an indication of the existence of an ancient channel.

The accompanying map (Figure 2) indicates the areas over which bedrock outcrops or lies very close to the surface. Most of the larger gaps between neighbouring areas of bedrock along the walls of the present channels indicate the positions of ancient channels, but many minor gaps undoubtedly represent only drift-filled embayments or a heavy sloughing of drift from above. The rock and surfaces along the present channels are not indicative of the slopes of the ancient bedrock surface because they represent new cutting by the streams. However, the higher parts of many of the areas of exposed bedrock do represent parts of the ancient rock surface. If lines are drawn from points on the higher parts of the area of bedrock outcrop on one side of a present stream to points of equal elevations on the higher parts of the area of bedrock outcrops on the opposite side of the present stream, these lines will in some cases give a fairly good idea of the contours of the rock surface before it was modified by the present stream and of the direction followed by the ancient channel.

All ancient buried channels do not carry important paystreaks. Many of the old channels have been thoroughly tested and did not yield sufficient values to warrant extensive working. On the other hand, some old channels, notably that which winds in and out of the present channel of Black Jack Creek and that lying northwest of Slate Creek below the big bend, apparently paid well. If, as seems probable, the gold is of local origin, the channels most likely to pay best would be those that are oldest and have been least affected by ice erosion. Younger channels, whether formed by interglacial or post-glacial streams, may be expected to carry gold in important quantities only in places where they cut old gold-bearing channels. Other sources of important gold deposits are believed to be the parts of the glacial drift that include original placer deposits but little removed from their former position by ice, and gravels that represent a reconcentration of such deposits.

Most of the present well-defined rock valleys probably follow courses that in general correspond to those of the oldest drainage, though the ancient streams may have been larger or smaller than the present. Valleys of this type include Manson above Kildare, upper Kildare, Slate (above the old camp), Black Jack, Mosquito, and the upper part of the small creek between the last two.

In the lower flat areas shown in the eastern part of Figure 2 the oldest drainage may have been greatly different from the present. The course of Manson River is unusual. It enters the area from the south, turns to the east, and in a short distance outside the area swings south again. The normal course would be towards the north where there are two large valleys, Slate and McCorkell. At present the latter is followed by relatively small streams, and it seems most reasonable to suppose that it was originally occupied by a stream of fair size. The difference in elevation between Manson River and the outlet of McCorkell Valley on Germansen Creek has not been accurately determined, but rough calculations suggest that the outlet is sufficiently low to permit of drainage of Manson River in that direction. Manson River may originally have flowed through McCorkell Valley, and much evidence supports such a belief. The trends of the upper parts of Kildare, Black Jack, Mosquito, and other valleys farther east, including Skeleton and Government Creeks, suggest that originally they were tributaries of a stream flowing north. The pay channels along Black Jack Creek, and along the west side of the lower part of Slate Creek, also trend north and are believed to represent parts of the ancient drainage system. Furthermore, the conviction of old timers is that all the channels go " down to the north." The rock surface dips in a general way to the north. The band of resistant rock in the east except in the canyon of Manson River shows a general slope northward. The features of this ridge alone strongly suggest that old Manson River did not cross the section shown in Figure 2 but flowed to the north; the present channel appears to have been cut high up the ridge because of an ice dam immediately to the north. Even the small resistant ridge to the west seems to show a general slope down to the north. The ridges now present between Slate Creek and Manson River and north of the former may be almost entirely drift. There are some features that cannot be readily reconciled with the view that the ancient drainage was to the north. However, despite the unfavourable features, it is believed that the hypothesis of a northward flowing ancient system of drainage is warranted and that it may be a useful guide for future prospecting.

It is possible that Manson Channel originally cut across Kildare either just above its mouth at the first big bend or somewhat higher up. If it flowed north to McCorkell Valley it may have cut across Slate Creek Channel below the old camp. Between the gap in the rock wall on the valley side and the present canyon of Manson River, across the resistant band of rock in the east, there is no apparent channel large or deep enough to have been occupied by an ancient Manson River.

The ancient Kildare Creek may have swung around close to the hill between it and Slate, and may have joined Manson before it reached the position of the present Slate Creek Channel. The ancient Black Jack Channel is believed to be defined by the paystreak as indicated in Figure 2. At least two other tributaries probably flowed across the relatively flat area between Slate Creek and Manson River. One of these probably carried the waters of Lost and Mosquito Creeks and the other the waters of the little creek to the west. The pay channel, which may cross Slate Creek at the big bend and continue along the west side, may represent the position of a tributary. It is possible that adit workings on Manson River previously noted are in a tributary that might link up with that of Slate Creek. It is possible that another channel of this system crosses Slate Creek, 1,200 feet above the big bend. The courses of tributaries to the east, such as Skeleton and Government Creeks, have not been studied, but it should be mentioned that the position and probable direction of these would make them more liable to very serious erosion by ice, and this probably would have caused extensive obliteration of old channels.

It seems unlikely that the old Manson River could have swung around and flowed west in Slate Valley. The most probable course, if it did go northward, is one directly toward and through McCorkell Valley. The southern end of this valley appears to be filled to a considerable depth with unconsolidated materials. If McCorkell Valley represents the position of the old channel of Manson River, the old channel might be expected to be preserved only in the section where it lies south of the hill to the north of Slate Creek. Beyond this point it would have been largely destroyed by the ice.

Upper Slate Creek is thought to have been glaciated and not likely to carry important possibilities for placer mining. The widening westward of this valley is due either to glaciation, which is the most reasonable conclusion, or to an original westward flow of this creek. Deposits that existed here may have been shifted by ice somewhat lower down the creek. The placers found along the south side above the dam are on an old rock bench or channel, and were probably in part reconcentrated from drift. Below the dam there is a considerable section of ground that in places has been shown to be rich. The gold here is believed to be largely from Slate Creek Channel and as a result of ice action is believed to have been disturbed and mixed with drift. The possibility of old Manson Channel crossing here is an important consideration. The facts that the central of the three big holes here carried the best values, that the present channel widens, that bedrock disappears, and that the rock base is deeper, may have some significance in this regard. The hills on either side so far as is known may be entirely drift. It would seem that mapping of the bedrock surface in this section by geophysical methods would be warranted. The deposits mined on the bench north of the river below this were probably in part reconcentrated from drift which had been mixed with the old Slate Creek placers. There are probably no channels crossing Slate Creek for 2,000 feet below the road crossing. At this point there is a channel trending northeast which might warrant further testing to discover whether it is one of the older pay channels. Just below the next bend there appears to be a channel on the north side which may correspond to one immediately to the southeast on the opposite bank. These appear to have been tested with no encouraging results. At the big bend there appears to be a channel on the point on the north side corresponding with one directly to the south. Although there is some doubt about this channel there seems to have been an important paystreak running through here and continuing on down the west side of Slate Creek, as if indicating the presence of an old pay channel. At the big gap in the west rock wall below the big bend there is much evidence of such a channel. For a stretch here the two channels are so close together that there is little rock between them. Mapping of the bedrock to the south and to the north of Slate Creek at the big bend would probably determine the nature of this channel and might lead to some extension of the old workings. It is possible that workings from Manson River were along this channel.

At the road junction below the big bend on Slate Creek the present channel is so wide as to lead to the belief that another conforms with it and, therefore, it may be that there is an extra channel just above in about the same position as one of the four channels just described or there may be only three instead of four. On the south side a short distance below the big bend and on the north side somewhat lower down there are gaps that appear to represent the position of old channels. These may be parts of the same old channel. They have been tested. On the north side at the last bend shown in Figure 2 there is a wide gap and below this Slate Valley widens greatly. It would appear that one big channel or several smaller ones enter the present channel, and below here conform with it. There has been much testing at this point.

The whole of the upper part of the basin of Kildare Creek shown in Figure 2 probably has a rock base not far below the surface with no very deep channels cut in it. There appears for instance to be no possibility that Manson waters originally flowed north through here. The first rock channel entering Kildare is the late glacial channel of Manson, now occupied by a small lake. Below this on the south side rock is not well exposed and there may be one or more old channels. Certainly in the bend there is one that is deeply cut. On the north side in the same section there also appears to be an old channel, and there may be another on the south side just below the bend. At the next bend on the north side there appear to be two. Lower down on the north side there is a very long gap filled with a tremendous thickness of drift. The relationship of these gaps is not clear; in the lower part of the section there appears to be some large and deep channels, but to the west there does not appear to be any possible course for other than small channels. It is possible that the water that formed the channels came along a course north of and parallel to Kildare Creek and (or) from the southwest. Just below the bend where the creek turns to flow southeast there appears to be a channel on the south side which trends toward the eastern part of the gap on the north side. Lower down for a long distance there are no rocks exposed on either side, adits into the west side indicate that the southern end of the rock found there peters out in a narrow rim which dips steeply to the southwest, and beyond this the rock surface on this wall is below the base of the valley. Thus there is room for important channels to pass through here.

The deposits of upper Kildare are believed to have resulted from reconcentration by the stream of disturbed concentration of the oldest system now in drift. These originally probably came from the old Kildare Channel, but the exact location of this is not clear. It may have occupied approximately the position indicated by the workings. The section of the creek in which the workings occur is not thought to be favourable for important placers. No placer workings occur between those on upper Kildare and those on Manson River, but it may be that deposits not yet discovered occur in this section. It is possible that old Kildare Channel crossed the present channel at the bend, where the lowest workings are situated or just below this, and entered Manson at the nearest point to the southeast (or elsewhere). The channel at both these points has been tested, but possibly not completely. Such a channel because of its southeastward direction might have been cleaned out by ice. On the other hand there is a slight possibility that a pay channel does occur.

The area of lower Kildare Creek is one of the most critical of the whole section. The large drift-filled gaps in this section have been known for a long time and much testing has been done, but apparently yielded no very encouraging results. That it was adequate to prove that all of the ground is barren is not apparent. In any search for placers in this section it would seem to be of considerable importance to explore this area sufficiently to place an interpretation on the features observed. It is worthy of special note that the surface of the two large outcrops on either side of the valley, about 1,200 feet above the mouth, strongly suggest a channel with low, sloping sides trending north. The lower part of Kildare could easily be examined by mapping the bedrock surface by some geophysical method, to determine whether a channel crosses and also to fix the position of the base of such a channel. If a channel is found to occur the values in it could be tested by drilling. Just below the right angle bend on Kildare another channel appears to trend northeast. However, it is so steep-walled as to suggest an interglacial origin rather than preglacial. The possible occurrence of buried channels above the bend and for a distance of about 1,600 feet would seem to be worthy of probing in any comprehensive exploration plan. North of the present channel there certainly is an old channel or channels. The study of this section would be difficult because of the rapid increase in thickness of the overburden northward. The important thing here again is to first determine the slopes of the bedrock surface.

On the north side of Manson River between the cut off to upper Kildare and the mouth of Kildare Creek there are a number of gaps in the wall-rock and each appears to be occupied by one or more old rock channels. Some of these may link up with those of Kildare Creek. On the south side there is little rock exposed, so that there may be old channels there too. The rock exposures in the vicinity of Black Jack Creek indicate that it is probable, with the possible exception of the lower part of the hydraulic pit area, that no important channel parallels Manson on this side.

Upper Manson River may never have had placer deposits, but the distribution of the known deposits suggests that this is not likely. The part southwest of the limit of Figure 2 may have been cleaned out by ice that came through the gap to the north. Just within the limit of the figure it would appear that the old Manson channel was close to the base of Black Jack Mountain, and there is a possibility of its being there still. However, the ground above the canyon at the highest workings seems to have been well tested without obtaining important values. It is believed that this part of the valley is not favourable for the discovery of placers. From the canyon down to Black Jack it is believed that the placers were largely the result of reconcentration by the river of slightly disturbed deposits included in the drift. To some extent the drift itself has probably been worked in the adits. It would appear that this ground was largely worked out. Some isolated pieces remain and in places there may be a considerable volume of low-grade ground, but the possibilities here do not seem to be very favourable. To the southwest of the workings where adits have been driven it seems likely that the ground is unfavourable.

In lower Black Jack Valley there are indicated many parts of old rock channels and it appears that three or more channels were cut in about the same position. Near Manson River three channels diverge and it is believed that one occupies the gap above the hydraulic pit and another the hydraulic pit.

The placer deposits of Black Jack are believed to be largely a preserved channel of the oldest drainage system. They probably are largely worked out. It is believed that above the old workings the old channel was cleaned out by ice and that there is little hope of paying placers. From reports and limited observation of the bedrock at the head of the hydraulic pit the preserved channel of the oldest system is believed to extend northwest to the nearest part of Manson River. This section has probably been largely worked out by drifting. Some ground between the drifts which has been opened up by the hydraulic pit has paid and may continue to pay in a small way. It seems likely that hydraulic operations ceased just prior to reaching the best ground, but the probable limited extent of ground not already drifted does not seem to warrant other than small expenditures in the pursuit of what gold may be left. The channel or channels uncovered by hydraulicking, if they are not the oldest, probably derived gold through cutting these. The reports of the Gold Commissioner do not indicate that the ground was very rich. It is probably largely worked out.

Below Black Jack to the bend above Discovery Bar on Manson the rock rises so rapidly and so high to the south that it is improbable that any important channel parallels the present channel on this side, and there is no evidence of any very important channel entering on this side. On the north side the rock surface is so low that gaps in the continuity of outcrops may not indicate the position of old channels. The rock surface for this section clearly dips away to the north, so that a channel or channels either parallel the present channel or trend to the north. In the big bend about 1,200 feet above Discovery Bar there is a great U in the rock surface which seems to trend eastward. This, and other surfaces up river, suggest glaciation, and it would appear that the glaciers released from the restriction of the hills to the north were capable in this section of once again cutting down into the rock. Northwest and northeast of Discovery Bar are two gaps in the outcrops which may indicate the positions of small, old channels. A great U-shaped depression trends eastward from opposite Discovery Bar, which again suggests a glacial gouge. Below the canyon here on both sides of the valley there are drift-filled depressions that appear to represent an old channel crossing the present channel, but the rock base seems to be so low that the course of such a channel is not apparent. It could have come down the hill from the south, but if the water flowed northward, as this would indicate, there is no break apparent in the rock to the north sufficiently large and deep to afford an outlet. However, there is a possible outlet below the big bend on Slate Creek. On the north side of Manson in the same position as the old rock channel is a late glacial channel. In places it cuts to the bedrock and just above the low gap to Manson there is the location of an old waterfall. Lower on Manson River on the north side there are only late glacial rock channels. On the south side there are no well-defined channels except that of Mosquito Creek and the general depression, which crossing the river here and extending to the north lies west of the resistant band of rocks forming the lowest canyon shown on Figure 2. This canyon has a decidedly young appearance.

The deposits on Manson River between Kildare Creek and Discovery Bar are mainly on the north side and have been reached by adits. The adits open in 1933 pass through glacial drift on a relatively flat rock surface. It is clear that the lowest part of the rock surface lies, in the main, north of Manson River. Whether the deposits lie in the drift or occur in gravel in an old channel parallel to the present one is, of course, not known. If the former is the case the deposits may be disturbed concentrations lying in the original old channel of Manson River or Black Jack Creek. If they occur in gravels they may be undisturbed in an old channel or reconcentrated in a later interglacial channel. The run of gold appears to cross, above Discovery Bar, to the south side of the river and to continue there to Mosquito Creek. If the oldest Manson River Channel was in about the position of the deposits then the explanation of these may be that they represent the original deposits disturbed by ice and by interglacial and post-glacial waters. If the original Manson Channel was elsewhere the deposits are more difficult to explain, but they may have resulted from reworking of old deposits that occurred higher up by interglacial streams. It is possible that small sections of pay ground still exist in between old workings, but it is probable that except in a small way any search for these will prove too costly. The chief hope of discovery of new deposits lies in the possibility of original channels trending northward.

The chief hope in the area shown in Figure 2 of the discovery of new and important placer deposits lies in the possibility of a northward trending and partly preserved original drainage. In Manson and Slate Valleys there are several places where geophysical mapping of the bedrock could easily be undertaken and where a clue to the course of the ancient drainage might be afforded. If these tests fail to be conclusive for or against the hypothetical drainage system some further geophysical work in the low, flat area between these creeks could be undertaken. If such a system is established its extension northward could be carried forward with little difficulty. Once the bedrock surface is defined the testing of the channels by drilling would be very simple, as the location of the bottoms where the pay would be likely to occur, if present, would be known. Any pay dirt that does exist almost certainly will lie at levels near those at which it has been found in the nearby channels of the present creeks.

The possibilities within the existing, deeply cut surface channels are very limited. The ground in the bottoms in most places is shallow and any pay has been fairly well worked out. Along Slate Creek some deep ground not worked out is known to exist. The lower canyon section of Slate Creek has fairly deep ground. Some of this is due to tailings. Whether it was tested and worked before it was covered with tailings was not ascertained. Before any attempt to mine these basal gravels is made it would seem to be of the greatest importance to do considerable drilling, as the values may be very erratic. Any pay dirt that lies readily accessible from the sides of the present channels has probably been largely worked out by drifting. The reworking of these areas by mechanical means is probably not feasible in most places because of a very heavy overburden of largely barren materials which would be very costly to remove. The fact that a large percentage of old workings were confined to shallow ground on rock benches may indicate that most of the ground was workable only under very favourable conditions. The use of any mechanical method of prospecting that employs the detection of the black (magnetite) sands as a criterion of the location of paystreaks would appear to have little hope of success, since there are probably bands of these in most channels whether cut in drift or bedrock. Thus there is probably an intricate network of magnetite streaks that might be expected to yield results of a most confusing nature, or the effect of streaks in the near surface and surface channels might be so strong as to make those at greater depth, which are the important ones, undetectable. Further, the mapping of the bedrock surface by mechanical prospecting is also most likely to yield results that without sound geological backing are too confusing to be of value. However, it is believed that the mapping of the bedrock surface in conjunction with a detailed study of the geology along the lines indicated may disclose valuable buried paystreaks. In most cases because of the overburden the recovery of such pay will involve deep mining.

The occurrence of the placer deposits strongly suggests that the gold is of local origin. So far no lode gold deposit of importance has been discovered or has been developed to such a state as to indicate economic importance. However, there are small deposits on Manson River and Germansen Creek that yield lode gold. Some very fine specimens of quartz-bearing free gold obtained in the district are owned by some of the old timers. Reports state that gold was ground out of the Germansen deposits, out of deposits on Slate Creek near the extensive tailing dumps below the big bend, and on Lost Creek. No accurate data are available about the last two deposits. Quartz-bearing sulphides occur throughout the area of the Manson placer deposits and sulphide veins occur locally. There is ample evidence in the occurrence of mineralization in general, and gold-bearing mineralization in particular, to suggest that the bedrock is sufficiently mineralized to have yielded the gold of the placer deposits.

The fact that no important gold deposits have been found might readily be explained in several ways. They may exist but may not have been discovered, since most of the bedrock of the area is obscured; there are great areas where important veins may exist with little hope of discovery. There is always the possibility that the veins from which the gold has been weathered have been completely removed. However, there are good reasons for believing that this is not the case, in fact there are some reasons for believing that the present rock surface is near the upper limit of the mineralized zone instead of near the lower limit.

WILLOW RIVER MAP-AREA, CARIBOO DISTRICT, B.C.: GENERAL GEOLOGY AND LODE DEPOSITS

By George Hanson

CONTENTS

INTRODUCTION

Gold-quartz veins of value have been discovered here and there within a large part of Cariboo district, British Columbia. The promise of finding commercial ore attracted the attention of many mining companies and drew many prospectors to the area, and the present desire for geological information is at a maximum. The district was covered in large part by a geological reconnaissance in 1885 by Bowman of the Geological Survey, Barkerville and vicinity were mapped in detail by Johnson and Uglow in 1924, and Quesnel Forks area was studied in 1932 by Cockfield and Walker. In 1933 detailed geological work was begun in Willow River area which includes the western half of Barkerville area.

Willow River map-area lies between latitude 53° and 53° 15′ and between longitude 121° 30′ and 122°. The western part of the area is 30 miles east of Quesnel, the northern terminus of the Pacific Great Eastern Railway. An automobile road connects Barkerville with Quesnel and passes through the southern part of the area. Other roads in the area are in poor repair. Short roads lead from the Barkerville road down Valley Creek to Stewart Creek, down Slough Creek to Dragon Creek, and down Willow River to Cornish Creek. A fair automobile road branches from the Barkerville road and goes to Bowron Lake. There are trails along most of the main streams.

Over most of the area a heavy forest growth and an almost unbroken mantle of drift obscure all but occasional rock outcrops. The geological formations are of such a nature, however, that it has been possible to locate roughly most of the formation boundaries and to decipher the general structure in the part of the area investigated during 1933.

The writer is pleased to acknowledge his indebtedness to W. E. Cockfield, with whom he was associated in the field, for assistance and guidance based on a broader knowledge of the general geology of Cariboo district. A. H. Buller gave efficient assistance. The writer also desires to thank Fred Wells, general manager of the Cariboo Gold Quartz Mining Company, Limited, for permission to examine the company's mine and for

full information regarding it; S. Atkinson, the superintendent, for help in underground work at the mine; and other officials of the company for information received. He also wishes to thank Bert Smith of the Premier Gold Mining Company, Limited, Wm. Smitheringale of the Cariboo Consolidated Gold Mines, Limited, and Angus McLeod of the Burns Mountain Gold Mines, Limited, for full information about the properties they were developing. The Department of Lands of British Columbia kindly supplied the writer with all their available geographic maps of the Cariboo.

GENERAL CHARACTER OF THE DISTRICT

The plateau region of British Columbia, of which Willow River area is a part, is bounded by the Coast Range on the west and by the Cariboo and other mountain ranges on the east. Johnston and Uglow[1] say, "The region is characterized by relatively flat-topped, inter-valley ridges, whose summit levels maintain a general accordance within the smaller units of the area, but over larger areas show a gradual change from 6,500 down to about 3,500 feet." The general level of the mountain summits of Willow River area has a gentle southwesterly slope from an elevation of 6,900 feet on Two Sisters Mountain in the east to 5,400 feet on Sovereign Mountain in the southwest. West of the map-area the general level falls rapidly to lower lying ground adjacent to Fraser River, the quick change in elevation coinciding approximately with a contact between the older, more resistant Cariboo series and less resistant Mesozoic rocks to the west, and it would seem that the western area is lower because the rocks there were more easily eroded. East of the map-area is a broad valley occupied in the south by Bowron River and Indian Point Creek. East of this valley is the lofty Cariboo Mountain Range.

The relief of the map-area is not great. The highest mountain is 6,900 feet high but no other mountain rises above 5,800 feet. The lowest elevation is 3,300 feet. There is no permanent ice or snow in the area. Timber-line is at an elevation of 6,200 feet.

The drainage in the eastern part is northeast to Bowron River and thence north to the Fraser above Prince George. Most of the northern part drains by Willow River and its tributaries north to the Fraser above Prince George. The southwestern part is drained by Lightning Creek which flows westward to join Cottonwood River, whose course is northwest to Fraser River. Some of the passes between the different drainage basins mentioned above are very low, and some of them are through valleys cut when the drainage of the area was different from that of today. For example Johnston and Uglow[2] suggest that Lightning Creek formerly ran northward through Beaver Pass, a low pass between Tregillus Creek entering Willow River, and Beaverpass Creek entering Lightning Creek. Work done during the past summer by placer interests shows that gravel terraces exist along Beaver Pass and have a northward slope, thus indicating that at one time the water did flow north through Beaver Pass. Somewhat similar passes exist at the head of West Creek, Hattie Creek, Valley Creek, and at other places.

[1] Geol. Surv., Canada, Mem. 149, p. 2 (1926).
[2] Geol. Surv., Canada, Mem. 149, p. 158 (1926).

All the larger streams in the map-area flow in flat-bottomed, drift-filled valleys. In most of the valleys where bedrock has been encountered in shafts or drill holes, the drift is 100 to 200 feet deep. The flat, drift-filled part of such valleys is commonly about 200 yards wide. Small lakes, formed at the time of the latest glaciation, are numerous in some of the valleys, particularly in Valley Creek.

A few cirques occur but are small and inconspicuous except on the northeast side of Two Sisters Mountain. Lightning Creek Valley is U-shaped up to a height of 500 feet above the stream.

GEOLOGY

The greater part of the area is underlain by the Cariboo series, believed to be of Precambrian age. The rocks of this series are mainly quartzites and argillaceous sediments metamorphosed so that they are now mainly sericite schists. Overlying these rocks in the eastern part of the area are sedimentary and volcanic rocks believed to be of late Palæozoic and of Mesozoic age. Overlying the Cariboo series at the western edge of the map-area are argillaceous and basaltic rocks of Mesozoic age. The formations strike northwest. The Mesozoic rocks extend southwest for many miles and the late Palæozoic and Mesozoic rocks on the east extend east for several miles. The Cariboo series extends southeast and northwest for long distances beyond the borders of the map-area.

The Cariboo series is the country rock of the gold-quartz veins of the area. Quartz veins also occur in the younger formation, in the northeastern and southwestern parts of the area, but do not appear to be of commercial value. The Cariboo series crosses the area from southeast to northwest in a band 15 miles wide and occupies 80 per cent of the area. The rocks before they were folded and subjected to alteration were mainly sandstone, argillaceous sandstone, and shale, and with these occurred minor amounts of limestone and conglomerate. The rocks are now grey to dark grey quartzites, grey quartz-sericite schists, white to light grey sericite schists, black, carbonaceous and graphitic schists, grey to dark grey, calcareous, sericite schists, greenish, argillaceous schists, sheared conglomerates, and limestone partly or wholly converted into marble.

The Cariboo series in the southeastern corner of the map-area was subdivided by Johnston and Uglow into three formations, the Richfield, the Barkerville, and the Pleasant Valley. According to these authors,[1] the Richfield is 8,000 feet thick and consists mainly of sheared quartzites and argillaceous rocks. The Barkerville formation is 2,500 feet thick and consists mainly of limestone and sheared clastic sediments. The Pleasant Valley is 5,000 feet thick and consists mainly of sheared argillaceous rocks. To the northwest the continuity of the formations is interrupted by a northeasterly striking fault with an apparent horizontal offset of 4 miles. Because of scarcity of outcrops, Johnston and Uglow were unable to subdivide the series northwest of the fault. In the district studied in 1933 it was also impossible to subdivide the series. The strata belong

[1] Geol. Surv., Canada, Mem. 149, pp. 11-15 (1926).

perhaps to the Richfield, but all the types of rocks composing the series are present, and none appears to be confined to any one horizon. It may be that essentially the whole series is present, and that the three subdivisions made in the southeast are not recognizable in the western and northern part of the area.

The quartzites commonly occur in massive beds, a few to many feet thick, some of which are practically unsheared and commonly break into coarse, angular talus. The quartzite commonly contains quartz grains larger than the usual grain of the rock and locally resembles quartz porphyry. In a few beds biotite is plentiful enough to make the rock very dark grey.

Impure quartzites and argillaceous rocks are common. They occur interbedded with the purer quartzites. They have been sheared more than the purer quartzites and in general are fairly completely altered to quartz-sericite schists, sericite schists, and graphitic schists. The individual beds vary in thickness from a fraction of an inch to several feet. The quartz-sericite schists contain much quartz and sericite. Some have much biotite, some contain actinolite, and many contain small amounts of feldspar, titanite, apatite, chlorite, iron oxides, and, less commonly, garnet and tourmaline. Most argillaceous rocks in the area are sheared, but in several places argillites and shales remain practically unsheared. The black graphitic schists have been derived mainly from argillaceous rocks.

The limestones and calcareous quartzites occur in zones 50 feet or more thick in some places. These calcareous horizons are probably fairly persistent but could not be followed far because of lack of outcrops.

A few beds of fine pebble conglomerate occur associated with coarse-grained quartzite.

In the eastern part of the area Johnston and Uglow found dykes and sills of quartz porphyry and other acidic rocks to which they applied the name Proserpine. They cut the Cariboo series but are older than the Slide Mountain series. The authors referred to believed that the gold deposits are related to these intrusives and to the larger bodies from which the intrusives came. Examples of the dykes and sills were not found in the part of the area examined during the 1933 season. They probably occur there, and scarcity of outcrops would explain why they were not found. Very much quartz porphyry float was found on the west side of Valley Creek north of Stewart Creek, so much indeed that it is very likely that this rock occurs in place there but is covered by a thin mantle of drift. It is not known that this rock belongs to the Proserpine dykes and sills but as acid intrusives of other ages are extremely rare in the area it may be Proserpine.

The Slide Mountain series differs from the older Cariboo series in several important ways. The younger series so far as known holds no mineral deposits of potential commercial value, whereas the Cariboo series has many. The younger series is in general well bedded and is sheared only locally and to a minor degree, whereas the older series rarely exhibits true bedding because stratification is masked by general shearing.

In Barkerville map-area Johnston and Uglow subdivided the Slide Mountain series into four formations except in the area northwest of Cornish Creek where, owing to lack of outcrops, the series was not subdivided. The subdivisions are as follows:

Antler formation: thinly bedded, white, red, and black chert interbedded with greyish green, indurated shales
Waverley formation: basic volcanic flows and breccias
Greenberry formation: crinoidal limestone
Guyet formation: basal conglomerate

In the area examined in 1933 the Guyet, Antler, and Greenberry formations were recognized, but lack of outcrops prevented accurate mapping of these formations. Basic volcanic rocks are abundant and may be allied to the Waverley formation.

Johnston and Uglow believed the Slide Mountain series to be unconformably above the Cariboo series. Imperfect fossils from the Greenberry formation date this part of the series as probably of Mississippian age.

The contact between the Slide Mountain and the Cariboo series strikes northwest to a northeasterly striking fault which offsets the contact 4 miles to the southwest. From that point the contact runs northwest along the west side of Hardscrabble and Wiley Mountains, crosses Sugar and Valley Creeks, and extends northwest beyond Willow Creek map-area. At no place was the contact observed, but the attitudes of the rocks on both sides suggest that it dips northeast at a low angle.

The Guyet formation in Barkerville area is a basal conglomerate. Johnston and Uglow state that it consists of a schistose conglomerate grading upward into a coarse, bouldery deposit in the middle part and a coarse-grained, gritty quartzite near the top. The formation was recognized with certainty only in the eastern part of the area, and at that place only the gritty quartzites were seen.

The Greenberry limestone was recognized only in the eastern part of the area about 2 miles northeast of Ninemile Lake. At that place the rock is a grey, crystalline limestone with a great many fragments of crinoids. Seams of chert occur locally, and locally reticulating veinlets of white quartz are numerous. White to grey limestone occurs also in the canyon of Stewart Creek and at the head of the canyon on Valley Creek. These bodies of limestone are about 200 feet thick, but contain more argillaceous beds than the typical Greenberry limestone and do not contain crinoid remains. These two isolated bodies of limestone are not definitely known to belong to the Greenberry, although they are probably part of the Slide Mountain series.

The Antler formation occurs over much of the northeastern part of the map-area. In this formation thin-bedded, grey to white cherts are the typical rocks. The individual layers of chert are commonly about 1 to 2 inches thick. Greenish grey shales are also characteristic of this formation. The rocks are intruded by many basic dykes and sills. The formation overlies the Greenberry limestone and Guyet conglomerate, but the actual contact was not seen. In general the formation is well bedded, unsheared, and only gently folded. Locally, however, shearing has produced a cleavage at an angle to the beds. Locally, too, some chert beds have been very severely contorted. The local, severe folding was observed at several places and in all such cases only a thickness of 10 feet or so of thinly bedded chert was plicated, whereas the overlying and underlying beds dip gently. Probably the folding was done prior to the final hardening of the beds into solid rock.

Crystalline basic rocks underlie several square miles in the northeastern corner of the map-area. The Antler formation dips east under these rocks, and if the crystalline rocks are lava flows they overlie the Antler formation. Exposures of these rocks are numerous and large, but the mode of origin could not be fully ascertained. Locally the rocks contain pillow-like structures, suggesting that they are lava flows. Locally, too, the rock is fragmental. A few thin sections examined under the microscope showed partly devitrified black glass. In one thin section the material resembles a fine-grained ash rock. In general, however, the rock is crystalline and devoid of structures typical of extrusive rocks. It would seem that much of the rock may be intrusive but that there are also extrusive facies. The crystalline rock types are very much alike in appearance and mineralogical composition, and all those examined in thin section are typified by the presence of much augite. Associated with the rocks are dykes and sills of similar mineralogical composition also typified by abundant augite. In the field, boundaries between dykes and larger bodies of the rock could not everywhere be seen, although exposures were excellent. The rock types are mainly basalts and gabbros.

The rocks contain inclusions of thin-bedded, cherty rocks of the Antler formation. Such inclusions were seen near the contact with the Antler formation. Irregularly shaped seams and streaks of black, cherty material occur locally. Dykes and sills of the basic rock cut the Antler formation.

Johnston and Uglow described an assemblage of basic flows and fragmental rocks which they considered to be part of the Slide Mountain series. They also describe basic sills and dykes younger than the Slide Mountain series and presumed to be of Mesozoic age. In the area studied in 1933 all of the igneous rocks appear to be younger than the Antler formation. Their age is unknown. They are probably either of Palæozoic or of Mesozoic age.

The southwestern corner of Willow River map-area is underlain by rocks of Mesozoic age. They lie along the strike and only a few miles northwest of rocks mapped by Bowman[1] as the Quesnel River beds, and there is very little doubt that they are the same. The Quesnel River group underlies most of the Quesnel Forks map-area and the various rock types included have been described by Cockfield and Walker[2]. In Willow River map-area the rocks are mainly black shales, but there are also thin beds of coarser clastic sediments and a few dykes or sills of basalt. The shales strike west-northwest and dip steeply. They are sharply folded into tight anticlines and synclines. Only a few thin basic dykes or sills were seen, but a short distance west of the map-area basaltic rocks are plentiful. Fossils found in the Quesnel River group by Bowman and by Cockfield and Walker show that the strata are in part of Jurassic age, and may be in part of Cretaceous age.

[1] Geol. Surv., Canada, Ann. Rept., vol. III, pt. I, pt. C, pp. 17-19 (1889).
[2] Geol. Surv., Canada, Sum. Rept. 1932, pt. A I, pp. 79-84.

The only accumulations of Tertiary age in the area are gravels, sands, talus, etc., in various stages of cementation. Deposits of this nature are rare.

Pleistocene accumulations consisting of boulder clay, morainal debris, boulders, stratified gravel, sand, silt, and clay are widely distributed over the area. Glacial erratics are not numerous but occur as high as 6,700 feet above sea-level. At some places on upland surfaces thin remnants of boulder clay were seen, and in some of the valleys placer pits expose thin deposits of boulder clay buried by stream deposits and later boulder clay.

An extensive accumulation of glacial drift occurs on the northwest side of Mount Tom. Locally this drift may be upwards of 50 feet thick. Mount Tom is 5,700 feet high and drift extends to the top. This drift has even slopes not typical of very young accumulations of drift.

Terminal moraines exist on Lightning Creek just below Beaver Pass and also 7 miles up the stream below Stanley. These moraines extend for a mile or so along the valley. The one below Beaver Pass appears to be more stony and somewhat less hummocky than the one below Stanley, and for these reasons, and also because it is farther down the valley, it would seem to be the older of the two. It is not known whether the two moraines represent halts in the retreat of the last Lightning Creek glaciation or two glaciations separated by a short time interval. On some of the creeks placer excavations expose two late tills separated by a few feet of stratified sands and silt. In these places the evidence although far from complete suggests that the two tills represent a minor retreat and advance of one glaciation rather than two stages of glaciation.

The youngest glacial deposits occur in most or all of the valleys. These late accumulations of boulder clay and morainal matter lie in the large valleys, largely, if not entirely, below an elevation of 600 feet above the valley floors. Placer cuts on the tributary streams give excellent exposures of these lateral moraines fringing the main valleys. On the west side of Two Sisters Mountain lateral moraines extend from the big valley of Valley Creek up the mountain 1,000 feet or more to the places where small glaciers formerly existed on the mountain side. Moraines of this nature were not seen on lower mountains.

The valley of Lightning Creek is U-shaped to heights of 500 feet or less. The other main valleys show the same characteristics but to a less marked degree. The U-shape of the main valleys, and the location of the latest glacial drift, suggest that the ice was only 600 feet deep in the valleys at the time of the last glaciation. Young moraines, as on Two Sisters Mountain, suggest that only the higher mountains supported mountain glaciers at that time. Bench gravels lying below younger boulder clay and above earlier glacial deposits have been traced by the Stevens-Langford interests from Lightning Creek through Beaver Pass to Aura Fina Creek and show a constant slope from Lightning Creek. In some part of the time intervening between the deposition of the two glacial deposits, therefore, Lightning Creek above Beaver Pass flowed north through Beaver Pass and so on down Willow River. The deposits are well exposed on Baldhead Creek about 3 miles north of Beaver Pass House. At an elevation of 100 feet above the present Beaver Pass summit, and lying on bedrock, is coarse stream wash 15 feet thick containing many glacial boulders. This early stream wash is largely the remains of an earlier boulder clay. The stream wash has been cut into by a later stream, leaving a stream gravel several feet thick consisting of well-rounded and even-sized pebbles. The early stream wash and later stream gravel are both gold bearing. On top of this is boulder clay of the last glaciation. Other similarly situated stream gravels are exposed in other placer excavations. Therefore, there appear to be two periods of glaciation separated by an interglacial period.

The restriction of young glacial deposition and erosion to low elevations shows that at the time of this glaciation ice was not present as a continental sheet but occurred only as valley glaciers. The abrupt change at elevations of 600 feet above the valley floors suggests that this younger glaciation was individual and not a gradual waning from a continental ice-sheet. The evidence furnished by the latest glaciation suggests that there were at least two periods of glaciation, one of continental type and the later of valley type. The glacial erratics and the thin accumulations of drift on the mountains must have been deposited by continental ice. The general unweathered nature of the boulders supports the idea that they are not part of a very old till. The scarcity or absence of glacial striæ on rock outcrops of the mountains, however, suggests that the last continental glaciation took place at a date sufficiently remote for the striæ to have been destroyed by weathering.

From the evidence seen in the Willow River area the writer is inclined to place the early glacial deposits exposed in placer cuts with the glacial erratics and thin accumulations of glacial drift on the mountains in an early glacial period, the glaciers of which were of continental type. The evidence goes to show that the latest glaciation was essentially of valley type and did not override the hills and mountains. It is possible, however, that all remains of the earliest glaciation have been removed, that the two periods of glaciation noted are close together in time, and that the interglacial period noted was of short duration.

Recent deposits consist of gravel, sand, and silt, and occur in the stream valleys. The main valleys have flat floors up to a quarter of a mile wide and underlain by such recent deposits. At several places in the area, for example on Valley Creek near Hattie Creek and on Tregillus Creek between Hyde and Berry Creeks, recent stream gravels a few feet thick lie on boulder clay about 50 feet above the present stream. In general the Recent deposits are not cemented, but presumably Recent gravels near the lower end of the canyon on Valley Creek have been so firmly cemented with a calcareous cement that boulders of this material have been carried unbroken a mile down Valley Creek.

STRUCTURE

The Cariboo series lies in a broad, northwesterly plunging anticline. On the northeastern limb lie northeasterly dipping rocks of the Slide Mountain series. Fifteen miles to the southwest, on the southwestern limb, are steeply dipping rocks of Mesozoic age.

The rocks of the Cariboo series are in general sheared so much that the attitude of the beds can not everywhere be ascertained. In many places, however, the beds can be seen, and there the strike and dip of the planes of shearing coincide approximately with those of the strata. In the southeastern part of the area the beds on the crest of the anticline are horizontal and the strike on both limbs is northwest. To the northwest, however, the anticline plunges northwest at angles of 20 to 45 degrees. The crest of the anticline becomes several miles across. The strikes of the rocks on the two limbs swing around in great curves to meet in northeasterly strikes at the crest of the fold. The strike of the rocks, therefore, in the northwestern part of the area instead of being mainly northwest is about west on the northeastern limb and north on the southwestern limb of the anticline.

The rocks of the Slide Mountain series have in the main a gentle to moderate northeasterly dip. Near the contact with the Cariboo series the rocks are in general sheared, so that they have a platy parting locally at a considerable angle to the beds.

The small area of rocks of Mesozoic age in the southwestern part of the area have in general a more westerly strike than the adjacent rocks of the Cariboo series. Near the contact the Cariboo series dips steeply southwest. The Mesozoic rocks are closely folded into anticlines and synclines with vertical and steep dips. The rocks are not sheared.

DESCRIPTION OF MINERAL DEPOSITS

The mineral deposits of Willow River and Barkerville areas are quartz veins, many of which are gold bearing. Johnston and Uglow pointed out that the veins of Barkerville area are of two types. One type consists of large veins striking northwest parallel to the strike and dip of the rocks, and have been called A veins. The other type consists of narrow veins striking northeast across the strike of the rocks, and have been called B veins. They concluded that the A veins were in general too low grade to be mined, but that many of the B veins were of high grade. This striking generalization could not be applied to the part of Willow River area studied in 1933 because there the rocks did not all have the same northwesterly strike. The names A and B could not be applied to the veins there with the same meaning they have in Barkerville area. There are, however, veins parallel to the strike and dip of the rocks, others crossing the strike of the rocks, and others parallel to the strike but dipping in opposite directions to the dip of the rocks. Development work is too scanty to justify any generalization in regard to the gold content of veins of different strike.

There are other points of interest that apply to the veins of the area. The quartz in some veins is coarsely crystalline and in many veins is glassy. The veins contain much pyrite and arsenopyrite, a little pyrrhotite, and minute amounts of rutile. They have, therefore, some features implying that they are of fairly high temperature type. The Cariboo series being very thick and consisting mainly of clastic sediments provided a uniform environment for ore deposition over broad areas and to moderate depth. The association of uniform geological conditions with veins of a high temperature type commonly results in great persistence in depth. The little that is known, therefore, suggests that development work at depth will find very little change in the mineralization of the veins.

WILLOW RIVER GROUP OF CLAIMS

The Willow River group, held in 1933 by Fred Wells, is near the mouth of Moose Creek, a small stream entering Willow River from the east side about 14 miles north of Beaver Pass House. The Beaver Pass trail is the present route to the property.

The country rocks are grey, quartz-sericite schist and sheared, black, argillaceous rocks of the Cariboo series, striking west to northwest and dipping steeply north or northeast. The location is on the northeastern limb of the main anticline of the Cariboo series about 3 miles from its crest.

Several quartz veins have been uncovered on the banks of Moose Creek. Three veins are exposed in trenches dug in 2 to 8 feet of overburden. Two of the veins vary in width with a maximum of 2 feet and where exposed strike west-northwest parallel to the shearing of the rocks. The third is 2 feet wide and where exposed in a trench strikes about north 70 degrees east, making an angle of approximately 45 degrees with the strike of the shear planes. A few hundred feet farther west on Moose Creek a body of quartz about 12 by 12 feet is exposed. This is part of a quartz vein which appears to strike northwest and to dip steeply northeast parallel with the shearing of the enclosing rocks. The argillaceous rocks near the veins hold cubes of pyrite, but the quartz is very sparingly mineralized. At the time of the writer's visit work had just been started, and the veins were very inadequately exposed.

BERRY CREEK GROUPS

Berry Creek enters Willow River from the west about 12 miles north of Beaver Pass House. There are three groups of claims at this place, the Ajax, Rex, and Lux groups, held in 1933 by N. Hanson and partners. The Beaver Pass trail is the route to the properties.

Only a few isolated rock outcrops were seen. They are of grey, quartz-sericite schists and calcareous schists of the Cariboo series, striking west to west-southwest and dipping north at moderate to steep angles. The location is on the northeastern limb of the main anticline of the Cariboo series about 2 miles from its crest.

The mineral showings consist of narrow quartz stringers exposed in Berry Creek and striking in the main northeast, and of larger bodies of quartz a few hundred feet above the crossing of the Beaver Pass trail. The quartz stringers are reported to contain some free gold. Some of the larger bodies of quartz are boulders, probably near their source, but two may be in place. One of these is 3 feet wide and 20 feet long and strikes northwest and dips 60 degrees northeast. It consists of white quartz sparingly mineralized with pyrite and containing some sericite. The other is 6 by 8 feet and appears to strike northeast and dip 60 degrees northwest. This body is also very sparingly mineralized with pyrite.

CANADA GOLD LODE MINING COMPANY

Four groups of claims were being prospected in the summer of 1933 for the Canada Gold Lode Mining Company. These groups are the Eagle

Mountain Gold Quartz, Dragon Mountain Gold Quartz, Jawbone Gold Quartz, and Tiger Gold Quartz. The properties are north of the Barkerville road 2 to 4 miles east of Beaver Pass House.

The country rock is mainly quartz-sericite schist and somewhat similar rocks of the Cariboo series striking northwest to northeast and dipping at various angles to the west. The location is approximately on the crest of the main anticline of the Cariboo series.

At an elevation of 4,800 feet on the east side of Timon Creek, two open-cuts, 100 feet apart on the Eagle Mountain Gold Quartz group, expose a 2-foot quartz vein striking northeast, dipping 45 degrees northwest, and lying parallel to the shear planes of the rocks. The quartz contains some pyrite and sericite. Low assays in gold are reported. Another open-cut, 150 feet away, discloses another body of quartz 3 feet wide and 8 feet long containing some pyrite and sericite.

On the west side of Timon Creek, on the Dragon Mountain Gold Quartz group, an open-cut at an elevation of 4,200 feet exposes a vertical quartz vein varying in width up to 2 feet and striking east. It is parallel, or nearly so, with the shear planes of the rock and contains some pyrite and sericite. Another open-cut, 200 feet higher and about ¼ mile farther north, exposes another 2-foot quartz vein striking east and containing some sericite. The strike of the rocks was not ascertained.

At an elevation of 3,900 feet on the east branch of Jawbone Creek on the Jawbone Gold Quartz group, a short tunnel exposes a quartz vein varying in width up to 6 feet. The rock and vein are so shattered that neither the strike of the rock nor that of the vein could be determined accurately. The vein appears to strike east and to dip gently south. The quartz is mineralized with some pyrite and a little galena.

At an elevation of 3,800 feet, ½ mile west of Jawbone Creek, a short tunnel on the Tiger Gold Quartz group exposes a quartz vein 3 feet or more wide striking north 10 degrees west, dipping 30 degrees west, and lying in sheared quartzite with approximately the same strike and dip. The vein is locally split into several veins. The quartz is mineralized with some pyrite and galena.

CANYON AND TYEE GROUPS

The Canyon and Tyee groups of claims are held by A. Drinkwater and associates. The Canyon group is on Sugar Creek below Little Mustang Creek, and the Tyee group is about 2 miles west. Access is via the Sugar Creek trail, and the distance is about 12 miles northwest of the Barkerville road at the foot of Jack of Clubs Lake. A short branch trail from Little Mustang Creek leads to the Tyee group.

On the Canyon group many quartz veins are exposed on the banks of Sugar Creek, either naturally or in open-cuts. They occur in rocks striking west-northwest and dipping about 40 degrees north. No vein has been traced for over 100 feet, and all are very sparsely mineralized with pyrite. Most of the veins are parallel to the strike of the enclosing rocks, but some strike north-northeast. Low values in gold are reported.

The showing on the Tyee group is a body of quartz 20 feet by 50 feet, containing some pyrite, galena, sericite, and inclusions of argillaceous schist. A small outcrop of argillaceous schist near the vein strikes west-northwest and dips 40 degrees north. The quartz body appears to strike northeast and dip 60 degrees northwest, but a cover of drift obscures relationships and it is not even certain that the quartz is in place. Low values in gold are reported.

COMSTOCK GROUP

The Comstock or Big Twelve group adjoins the Tyee group on the north, and is about 12 miles northwest of the Barkerville road at the foot of Jack of Clubs Lake. Access is provided by the Sugar Creek trail and a short trail from Little Mustang Creek. The owners are Messrs. Sparling, Riley, and others of Barkerville.

The country rocks are sheared quartzites and conglomerates, probably of the Cariboo series, striking west-southwest to west-northwest and dipping about 40 degrees north. Three groups of veins are exposed in open-cuts, shafts, and tunnels.

A vein 18 inches wide is exposed in open-cuts and strikes east and dips 70 degrees south. This vein cuts across the strata making a small angle with their strike and a large angle with their dip. It has been traced for 100 feet. The western open-cuts disclose four narrow veins, indicating that the 18-inch vein either splits to the west or that other parallel veins begin there. About 100 feet north an incline shaft 10 feet or more deep exposes a 4-foot quartz vein striking northwest, dipping 45 degrees northeast, and lying parallel to the strata. About 100 feet farther north a 50-foot tunnel driven southeast cuts a body of quartz 8 or more feet wide. This vein appears to strike west-northwest parallel with the strike of the rock. An open-cut 200 feet northwest exposes vein quartz that may belong to this vein. The veins are sparsely mineralized with pyrite and galena and contain some sericite. Low values in gold are reported.

PREMIER GOLD MINING COMPANY, LIMITED

The Premier Gold Mining Company, Limited, was prospecting and developing holdings in several different places in 1933, but the writer saw only the ground on Cooper Creek.

The mineral claims visited are on Cooper Creek, a short stream entering Sugar Creek from the west. Access is over the Sugar Creek trail and branch trails up Cooper Creek, a distance of 10 to 11 miles from the Barkerville road at the foot of Jack of Clubs Lake.

Country rock consists of sheared quartzites and argillaceous rocks of the Cariboo series striking northwest and dipping from 20 to 70 degrees northeast. The veins range in width from a few inches to 30 feet. Some of the narrower veins are locally well mineralized with pyrite, galena, and pyrrhotite. Some contain sericite and one or two contain a little chalcopyrite. Some veins are drusy. Low values in gold are reported, particularly from the veins that are mineralized with sulphides, but no commercial gold ore has yet been found. None of the veins has been explored to a depth greater than 10 feet.

Some of the veins are parallel to the strike and dip of the country rock, others are parallel to the strike but dip in the opposite direction, and many crosscut the rocks at various angles to both strike and dip. One or two of the crosscutting veins appear to cut veins paralleling the rocks, but this point could not be established conclusively.

Most of the veins are on the east side of Cooper Creek, and no vein has been traced across the creek. This suggests that a fault strikes northeast along Cooper Creek. Geological work farther northeast along Sugar Creek also indicates the existence of such a fault and that the northwestern fault block is offset to the southwest.

BURNS MOUNTAIN GOLD QUARTZ MINES, LIMITED

The property of the Burns Mountain Gold Quartz Mines, Limited, is the old Perkins group, at an elevation of 5,200 feet on Burns Mountain about 2 miles east of Stanley.

The rocks on the property are sheared quartzites and quartz sericite schists of the Cariboo series striking northwest and dipping gently northeast. On a hill-side sloping gently to the west pits, shafts, and trenches were made many years ago on three parallel quartz veins that are 25 feet apart and strike north-northeast and dip steeply west. The veins were followed on the surface for 200 feet or more along their strike. Seventy-five feet lower a tunnel was driven toward these veins and a raise put up to the surface. Gold ore was mined from the veins. The company is continuing the tunnel, but so far has encountered only narrow quartz stringers. These stringers strike north-northeast and dip 70 degrees west. Cube pyrite is very plentiful in the rocks near the veins.

About 1,500 feet north are other old workings tracing a quartz vein for a distance of 500 feet. The lower part of this vein strikes east-northeast and the upper part north-northeast. This vein, also, was mined, but no recent work has been done on it.

About 500 feet east of the camp is a quartz-ankerite vein striking northeast. The ankerite appears to occur chiefly near the walls of the vein.

About 2,000 feet southeast and 300 feet below the camp, the company is driving a crosscut tunnel northwest. This tunnel is now 600 feet long, but so far has encountered only narrow quartz stringers.

Mining on a small scale was carried on at the property for several years after 1878. Good ore is reported to have assayed $30 to $120 in gold.

FOSTER LEDGE GOLD MINES, LIMITED

The property of the Foster Ledge Gold Mines, Limited, consists of the old Foster group, and is on Chisholm Creek about 2 miles north of Stanley.

The country rock consists of sericite and argillaceous schists of the Cariboo series, striking north and dipping 30 degrees east. Several narrow quartz veins striking north or slightly east of north and dipping 70 degrees west are exposed on the banks of Chisholm Creek. The veins have been traced for about 100 feet and contain pyrite, galena, sphalerite, and free gold. At this locality an old shaft on Chisholm Creek is reported to be 56 feet deep and to have been sunk on two 5-foot veins 4 feet apart. About 400 feet south of the shaft, and about 100 feet lower, a tunnel has been driven 225 feet north. The tunnel is probably on the foot-wall side of the veins unless they are offset by a fault. It is reported that samples have assayed up to $700 a ton in gold.

CARIBOO CONSOLIDATED GOLD MINES, LIMITED

The property of the Cariboo Consolidated Gold Mines, Limited, is on Island Mountain west of Jack of Clubs Lake. Parts of the holdings have been referred to in the past as Walker's ledges, Enterprise Company, Island Mountain Company, Island Mountain ledges, John's ledges, and Aurum group. The property has been described in various governmental reports and rather fully in Bulletins Nos. 1 and 3, 1933, of the British Columbia Department of Mines.

The country rock on the property is mainly sheared quartzite and sheared argillaceous rocks. There are, also, a few thin beds of grey limestone and a few beds of knotted schists in which the knots consist of ankerite. The rocks belong to the Cariboo series. They strike from southwest to northwest, but at most places a few degrees south of west. The dip in most places is about 30 degrees north but varies from 10 to 45 degrees.

Most of the deposits so far discovered are developed by tunnels. The entry to the Main tunnel is near the north end of Jack of Clubs Lake and 80 feet above it. It runs west for 160 feet and there forks: one branch continues southwest for 275 feet, another west for 400 feet, and the third northwest for 1,000 feet.

The west branch of the Main tunnel passes beneath the Middle tunnel, a short tunnel 280 feet above the Main tunnel.

The face of the west branch of the Main tunnel is 150 feet east of, and 350 feet below, the entry to the Upper Lake tunnel. This is also a short tunnel running westerly.

The northwestern branch of the Main tunnel if continued would pass under two tunnels known as the John's tunnels. In early September, 1933, the face of the northwestern branch of the Main tunnel was 120 feet distant from a point vertically below the lower of the two John's tunnels. The lower John's tunnel is 470 feet above the Main tunnel, is short, and runs westerly. The upper John's tunnel is 30 feet higher and a short distance north of the lower John's tunnel; it also is short and runs westerly.

Two bodies of quartz that may be parts of a single easterly striking quartz vein are exposed in the Upper Lake tunnel. In the western branch of the Main tunnel a quartz vein was followed for 200 feet. It strikes east-northeast and is on approximately the same line of strike as the vein in the Upper Lake tunnel. The main tunnel near its portal follows a quartz vein striking east-northeast for a distance of 40 feet; this vein is only a short distance from the line of strike of the other veins, and all may be parts of a single vein.

The two John's tunnels are drifts, each about 200 feet long, along quartz veins striking east to east-northeast. The veins are practically in line and may be slightly offset parts of a single vein. The northwest branch of the Main tunnel crosscuts four veins, each of which is 2 feet or more wide. They strike east-northeast to northeast. The one nearest the face is at the place where the John's vein would cross if it continued down on a 60-degree dip.

Nearly all the veins dip 60 degrees or more steeply to the south or southeast. One dips steeply northwest. All the veins mentioned are 1 to 5 feet wide and are well mineralized with pyrite and arsenopyrite. Locally, sulphides make up about 25 per cent by volume of the vein matter. Very rarely small nests of two unidentified bismuth-lead-copper sulphides occur in the veins. Arsenopyrite is locally fairly common. Ankerite in small amounts occurs in most of the veins. Free gold occurs but is not usually visible in hand specimens. Thin seams of rutile occur very locally. Pyrite is the common sulphide and it occurs in cubes in the vein and wall-rocks. No other wall-rock alteration is noticeable.

Besides the veins mentioned there are fifty or more veinlets up to 3 inches wide exposed in the underground workings. The veinlets strike from east-northeast to north-northeast and in general dip steeply south or southeast. A noticeable characteristic of the veinlets is that they occur in groups rather than as isolated individuals. This mode of occurrence suggests that each group may consist of branches from a single vein and that somewhere along the strike (or dip) they may coalesce to form a single vein. Some of the veinlets contain considerable pyrite and, as determined by assays, these in general carry good values in gold.

At one place in the Main tunnel a vein in sheared quartzite continues to a bed of limestone and calcareous schists about 6 feet. The vein and fracture die out in the limestone, but reappear on the other side. A possible explanation of this behaviour is that the rocks may have been buried so deeply at the time of fracturing that though the sheared quartzite fractured, the limestone being less rigid yielded to the stress by flowage rather than by fracturing.

Most of the veins carry good values in gold and if they prove to be persistent in length and depth may be mined profitably. The ground is considerably faulted, however, and much development work will be necessary to block out ore-bodies.

CARIBOO GOLD QUARTZ MINING COMPANY, LIMITED

The holdings of the Cariboo Gold Quartz Mining Company, Limited, are east of Jack of Clubs Lake on Cow Mountain. Two of the main surface showings were known long ago as the Sanders or Rainbow ledge and the Pinkerton ledge. The company took over the property in 1927 and commenced work to develop the veins at depth. The early work of the company was a drive from the Lowhee Creek side of Cow Mountain to cut the Sanders and Pinkerton veins. Work on this tunnel was abandoned in 1930 and a much longer tunnel 375 feet lower was commenced from Jack of Clubs Lake to penetrate the showings at a depth of approximately 600 feet. Since 1930 most of the development work has been done on this main level. Early in January, 1933, the company commenced milling ore extracted during the course of development and has since been treating about 60 tons daily.

The property has been mentioned in many governmental publications and has been very well described in Bulletins Nos. 1 and 3, 1932, of the British Columbia Department of Mines.

Country rock consists of sheared, grey quartzites and interbedded, argillaceous and coarser clastic rocks. Thin beds of limestone occur but are uncommon. The rocks belong to the Cariboo series. The shear planes coincide approximately with the bedding and strike west to west-northwest and dip 30 to 50 degrees north.

The surface showings are mainly on the Rainbow, Pinkerton, and Cariboo No. 1 mineral claims. Most of the open-cuts are old and do not now expose the veins sufficiently to show their lengths or widths. Abundant quartz float on the hill-side facing Jack of Clubs Lake suggests that a large quartz vein, indicated in the open-cuts on the Cariboo No. 1 claim, strikes west-northwest towards the lake.

The tunnel at the upper camp was driven prior to 1930. Some of the ore milled comes from this tunnel. It consists of the main drive and branches with a total length of 1,300 feet. The tunnel cuts several quartz veins from 1 to 2 feet wide, one much wider quartz vein, and many quartz veinlets. The veins and most of the veinlets are well mineralized with pyrite. Local pockets of two unidentified lead-copper-bismuth sulphides associated with a telluride occur in the veins, particularly in the large vein. These nests contain also a much greater quantity of free gold than the average of the veins. The large vein strikes approximately northeast. Most of the veins and veinlets in the tunnel strike north-northeast.

Most of the development work done in the last three years has been on the main tunnel, driven from a point 100 feet above Jack of Clubs Lake, southeast toward the surface showings on the Rainbow and Pinkerton claims, and on four other levels connected with the main tunnel and driven in the same direction; three at intervals of 110 feet above the main tunnel, and the fourth 115 feet below the main tunnel. The distance from the portal to the surface exposures on the Rainbow claim is approximately 2,500 feet, and to those on the Pinkerton, 3,500 feet. The surface exposures on the Cariboo No. 1 claim are about 1,200 feet south of the other main surface showings, and if the large vein exposed there strikes north-northwest, as is suggested by float, it will lie approximately parallel to the main tunnel and 1,200 to 2,000 feet southwest of it.

The main tunnel, known as the 1,500 tunnel, goes south for 450 feet and then southeast for 1,450 feet (September, 1933). The parallel levels above, known as the 1,400, 1,300, and 1,200 levels, are 200 to 400 feet long, and their faces are 500 feet farther from the objectives than that of the 1,500 level. These levels are connected with the main tunnel by an incline raise. Only the uppermost one is open to the surface. The one below the main level is known as the 1,600 level and in September, 1933, had just been started from an incline winze.

Although the primary objective of the 1,500 tunnel was the development of the Rainbow and Pinkerton showings, the management of the company believed that other veins might be encountered on the way. This belief was based on the presence of gold-bearing float at several places on the hill-side above the proposed site of entry. The faith of the management has been amply justified, as nine principal veins have been encountered, the outcrops of which were covered with drift. No. 1 was cut at 280 feet, No. 2 at 460 feet, No. 3 at 540 feet, No. 4 at 1,020 feet, No. 5 at 1,100 feet, No. 6 at 1,140 feet, No. 6½ at 1,160 feet, No. 7 at 1,180 feet, and No. 8 at 1,380 feet. Several other quartz veins 1 foot or more wide and probably more than a hundred veinlets 4 inches or less in width are also exposed in the tunnel.

The nine principal veins are very well mineralized with pyrite, some of them hold locally 50 per cent pyrite by volume, and all have 10 per cent or more. The pyrite is typically in cube form. In some veins the pyrite is very plentiful in the outer 6 or 12 inches on each side of the vein, and the centre almost free from the sulphide. In others the central part has the most sulphide and the outer parts very little. Light tan-coloured ankerite occurs in all the veins but is not plentiful. It appears to be more plentiful in branch veins than elsewhere. Arsenopyrite is fairly common but galena and sphalerite are rare. Black, fibrous mineral aggregates, consisting of two unidentified lead-bismuth-copper sulphides, occur locally in the veins associated with much free gold and a small amount of telluride. Free gold occurs throughout the veins, probably mostly as very small grains, but partly in irregular, oval nuggets up to the size of a pea, as wiry bunches weighing up to an eighth of an ounce, and as flat pieces ranging in size from very small up to nuggets one-tenth of an inch in thickness and weighing up to a quarter of an ounce.

The veins are typically branching, the branches making all angles, but mostly large angles, with the main vein. Veins from 1 to 5 feet wide have many wedge-shaped branches that are up to 3 feet wide where they commence, but taper rapidly and pinch out in distances of 30 feet. As a rule such wedges consist of quartz with very little pyrite. Exceptionally, they have local areas a few feet long containing very much pyrite. Other branches are persistent, and, although ordinarily not more than a foot wide, they continue for greater distances than the wedge-shaped masses, and more resemble the veins. There are, also, many narrow branches ending in 10 feet or less. Many of the branch veins, where they have narrowed to widths of a few inches or less, contain an unusual amount of ankerite. This mineral occurs in the outer parts of the branches and the quartz is in the centre.

The individual veins have fairly regular strikes and dips, but most of the branches have no regularity whatever. Most of the veins and branches occur at slight but sharp bends in the sheared rocks. The great number of branch veins, their lack of regularity in strike and dip, and their tapering forms are characteristic features.

The principal veins are fairly persistent both along the strike and dip, but commonly they split into several veins which may reunite again in a short distance, or the vein may finger out into gradually tapering veinlets continuing along the same strike as the vein. Locally a quartz vein may pinch out, but much pyrite may be present in rock for some distance along the continuation of the vein.

The abundant, narrow veinlets that occur throughout the underground workings are, considering their size, apparently very persistent. In this respect they resemble the veins and differ from the branches. They appear to have filled and partly replaced the walls of persistent joints in the rocks.

Two of the principal veins, Nos. 2 and 7, strike east and dip steeply north. No. 2 vein has been followed by drifts for 600 feet and No. 7 for 150 feet. Veins Nos. 3, 4, 6, and 6½ have not been followed by drifts. No. 4 vein appears to strike east and the others northeast. No. 1 vein has been drifted on for 100 feet, No. 5 for 150 feet, and No. 8 for 150 feet. These three veins strike approximately northeast and dip steeply northwest. The veinlets strike northeast, except for five or six that strike east. Those striking east are larger than the others and may be allied to the easterly striking veins.

The direction and nature of the vein fractures suggest that they form three sets. Two of these make an angle of 45 degrees with one another. Those of one of these two sets strike east and are not numerous, but may be more persistent or stronger than those of the other set. The other set of fractures strike northeast, are very numerous, and most of them are short, but some may be persistent. These two sets of fractures may have been formed by the same stresses and the stresses were probably compressive. The third set is represented by the twisting fractures filled by the branch veins. These fractures appear to have originated in a different manner and may have been formed in local areas of tension produced during the time of, and as a result of, the action of the compressive stresses.

The suggested relationship of the fractures is based solely on observations in the main working of the Cariboo Gold Quartz mine and are offered as suggestions only and not as being established. Further development work in this mine, and throughout the district in general, may show that the veins have different relationships.

An attempt was made to learn if any relationship existed between the type of fracture and the type of rock or the extent of shearing of the rock. It was felt, however, that the available data were too meagre to warrant drawing any deductions.

At the time the veins were formed, constituents forming pyrite also found their way out into the wall-rocks for several feet and formed cubes of pyrite. Locally near veins, small areas 2 or 3 feet across are almost completely replaced by cube pyrite. Some of this pyrite assays well in gold. It is possible, therefore, that local areas of country rock, or bands of country rock, may have been converted into gold ore.

There is some indication that where veins are close together, as between No. 5 and No. 7 veins, a large block of ground containing several veins might be mined as a whole. A winze was sunk in No. 5 vein and this zone was crosscut 115 feet below the 1,500 level. Several veins on this sub-level (1,600 level) are close together in severely sheared rock. Assays indicate a width of 50 feet of commercial ore. Several faults, probably of very small throw, cross the zone and there may be some widening of the ore zone as a result of repetition caused by the faults.

A northerly striking and easterly dipping fault crosses the 1,500 level between No. 7 and No. 8 veins. The higher mine levels are east of the fault, and the veins exposed in these levels have not been correlated with any of those on the 1,500 level. No precise information was obtained regarding the movement along this fault, but the positions of similar beds on opposite sides of the fault indicate a horizontal offset of 400 feet, those on the east side being offset to the south. Such an offset could be caused by horizontal movement to the south, or by downward movement of the block on the east side, or by a combination of the two movements.

The country rock is cut by many joints, many of which strike northeast parallel to the veinlets. Two thin limestone beds were noted underground, and in these rocks the joints did not show. The same suggestion is offered as in the case of the Island Mountain veins of the Cariboo Consolidated Mining Company, Limited, namely, that when the joints were formed the limestone flowed instead of fracturing.

ORIGIN OF THE PLACER GOLD

The origin of the placer gold was discussed very thoroughly by Johnston and Uglow in Memoir 149. They believed that the gold in the primary parts of the veins occurred associated with sulphide, but not in the free state. It was concluded, therefore, that oxidation of the veins freed the gold, and that the placers were formed from the oxidized parts of the veins. Since their report was written deep development on quartz veins has shown that free gold is plentiful in the veins at depth far below the influence of oxidation. The quantity of coarse gold in the primary veins was shown very strikingly at the Cariboo Gold Quartz mine. After a three-months' run the lining of the ball mill was changed. The quantity of ore milled in that time was 5,800 tons and the quantity of free gold taken out of the ball mill was 100 ounces. Much of this gold had been pounded in the mill, but many pieces had been caught in the lining of the mill and had not been distorted at all. The largest nugget weighed a little more than a quarter of an ounce. Although free gold was plentiful in oxidized vein outcrops, it is obvious that unoxidized veins could also supply gold to the placers. This being so, glacial erosion is a factor that must be considered in the formation of placers. Glaciers erode quickly, and grind much of the rock to a flour and thus would liberate the gold.

WILLOW RIVER MAP-AREA, CARIBOO DISTRICT, B.C.: PLACER DEPOSITS

By W. E. Cockfield

CONTENTS

Illustration

INTRODUCTION

Willow River map-area (latitudes 52° to 52° 15′, longitudes 121° 30′ to 122°) includes the western half of Barkerville map-area (Map No. 2046). The placer deposits of Barkerville area have been fully described by Johnston and Uglow (4). The present report, therefore, deals only with the placers of the area to the west, included in the western part of Willow River map-area. In this western district placer mining has not been nearly so extensive as in the adjoining Barkerville district. The main valleys, such as Lightning Creek and Willow River which cross the area under discussion, were worked in Barkerville area, and in the case of Lightning Creek and the main tributary of Willow River, Williams Creek, proved highly productive. As the wider and lower parts of the valleys were approached, the old buried channels were found to be deeper, and, speaking generally, poorer in gold content, and attempts at drifting along these old channels toward their lower ends in Barkerville area did not, in general, prove financially successful. The deeper and wider parts of these valleys in the part of Willow River area here discussed have, therefore, attracted little attention. Gold has, however, been recovered from many of the tributary streams.

The placer gold of the district may occur in a number of different ways, as stated by Johnston (4, pages 50-52). (1) Placer gold may occur in ancient stream gravels resting on bedrock and covered with glacial drift. No deposits seen in any of the mine openings of the area under discussion could be definitely referred to this class. A few deposits, more particularly those occurring in narrow, steep-sided gulches such as Boulder, Donovan, and Lovett Creeks, may possibly belong to this class, as the gold in these cases appears in a paystreak lying beneath boulder clay. It should, however, be pointed out that only a single stratum of boulder clay overlies these deposits, whereas distinct evidence has been obtained in Barkerville area and elsewhere in Cariboo district that there were several advances of the ice. Consequently, the deposits in question could very well be interglacial, the pre-existing boulder clay having been removed by erosion. It is probable, however, that pre-Glacial gravels do exist in the area in deeply buried channels in some of the valleys.

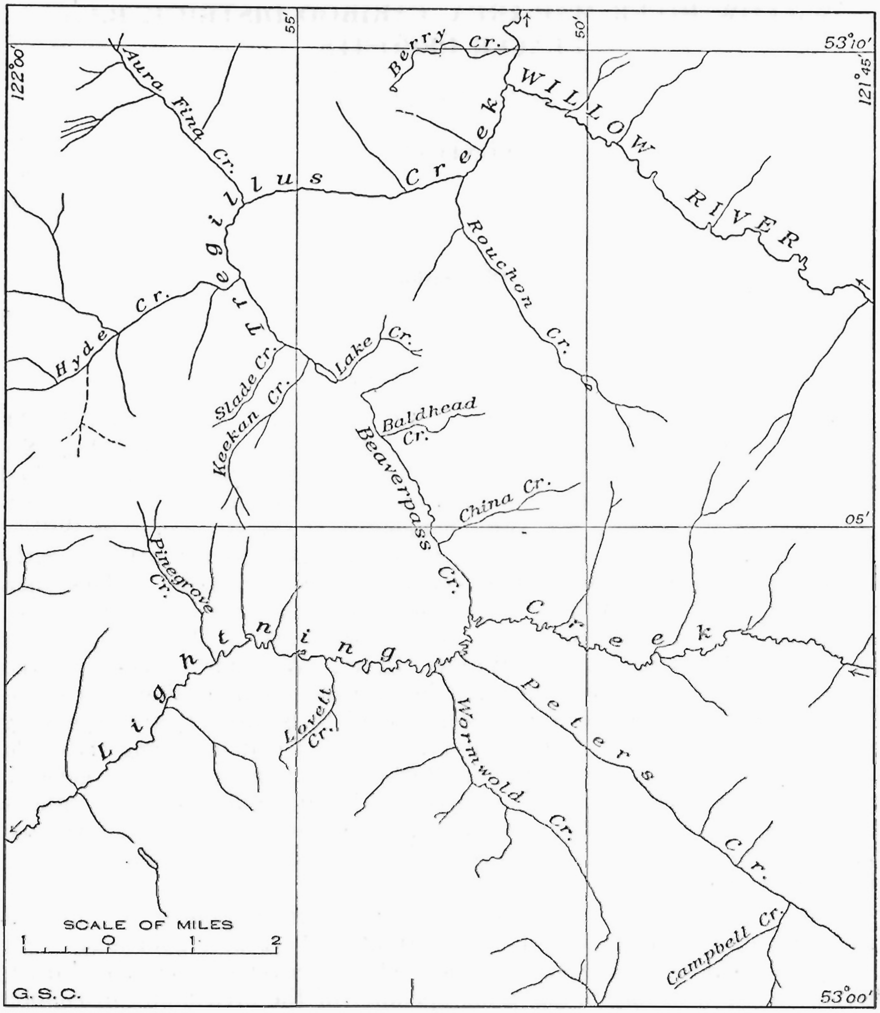

Figure 3. Showing location of streams in part of Willow River area, Cariboo District, British Columbia.

(2) Placer gold occurs in gravels on bedrock benches found at various elevations above the valley bottoms. These benches were formed when the streams stood at higher elevations than at present, and may be either pre-Glacial or Glacial stream courses. The gravels as a rule are glacial or inter-glacial.

(3) Placer gold may occur underlain and overlain by boulder clay. No such paystreak was noted in the area, but some deposits of gravel resting on bedrock and overlain by boulder clay are inferred to be interglacial, derived by the erosion of pre-existing boulder clay. This mode of origin is deduced from the fact that such gravels carry numerous boulders deemed to be glacial erratics.

(4) Gold occurs in the glacial drift, but deposits of this class are not of economic importance except where the drift carries masses of earlier gravels embedded in it. No such instance was noted.

(5) Post-Glacial gravels carry in places important amounts of gold. Such deposits include parts of the gravels of the present stream beds, and also gravels carrying gold on some of the benches, in places where the streams in cutting down through the former valley bottoms effected concentrations of gold from the drift deposits destroyed in the process. The gold occurring in the bed of a stream may be the result of the concentration of gold contained in the drift deposits and, more rarely, the result of the stream cutting across a pre-existing paystreak. The post-Glacial stream deposits may lie either on bedrock, or on a false bedrock of glacial materials. Gold concentrated on the bars of the main creeks and streams also belongs to this class. The post-Glacial concentrations were in some places quite rich.

DESCRIPTIONS OF CREEKS

LIGHTNING CREEK

This creek has been in the past one of the main producing streams of the Cariboo, but this production has come almost entirely from the upper part of the creek within Barkerville area. The present report deals only with the part from Jawbone Creek downstream to a short distance below Wingdam.

The valley of Lightning Creek above the town of Stanley is narrow and steep-sided, but below Stanley is comparatively wide and flat-bottomed as far as Beaver Pass House, a distance of 7½ miles. Below Beaver Pass House the valley is somewhat narrower and steep-sided, and continues with this character to below Wingdam. From Beaver Pass House downstream the creek has cut a narrow trench in glacial deposits, leaving benches of these materials on either side, and the depth of the trench increasing as Wingdam is approached. Below Wingdam the stream flows in a rock canyon. In the wide part of the valley, above Beaver Pass House, tailings from placer workings higher up the creek and on the benches have been deposited over considerable areas, thus forming flats over which the stream changes its course in high water. At Beaver Pass House, what appears to be a continuation of the main wide valley swings off to the north. This valley is occupied by Beaverpass and Tregillus Creeks, and has a scarcely perceptible grade from Lightning Creek to the summit. It is possible that Lightning Creek at one time drained to Willow River by way of Beaver Pass, but, although this theory finds more or less common acceptance in the area, it cannot be proved as the depths to bedrock at points along Lightning Creek and Beaverpass Creek are not known.

The only mining operation in progress along the stretch of Lightning Creek covered by this report is that of the Consolidated Gold Alluvials of British Columbia. This company was incorporated about 1930 and is stated to control 22½ miles of Lightning Creek. The only point at which work is being done is Wingdam.

At Wingdam work had been carried on by the Lightning Creek Gold Gravels and Drainage Company and other companies for a period stretching from 1898 to 1926. Over this period a large amount of money was expended on sinking shafts, drilling, and installing pumping equipment. The operations as recorded in the B.C. Minister of Mines Annual Reports were marked by a series of stops and starts, and by a failure each time the company was in a position to mine. The property was not by any means continuously worked during this period. The objective was to mine the deep channel believed to exist along Lightning Creek at this point and which, according to drilling records as reported by the company, carries high values. Three or more shafts were sunk and drifting was started from some of them, but on each occasion the water pressure encountered was such that the attempts to mine had to be abandoned.

Recently a drift has been run from the uppermost shaft, No. 2, along a paystreak supposed to lie some 50 to 60 feet above bedrock. The paystreak is shown by the workings to be about 100 feet wide, and has been followed by drifts for about 400 feet. The gravels being mined probably are an interglacial concentrate resting on a cemented stratum. The gravels contain numerous large boulders which are almost entirely of the local bedrock, but many of the smaller pebbles and boulders are foreign to the vicinity. The gold varies from coarse to fine, but is nearly all flat.

BOULDER CREEK

(*See also* B.C. Minister of Mines Annual Report, 1931)

Boulder Creek enters Lightning Creek about 3 miles below Stanley. It is a small stream with a steep grade. About 400 feet in elevation above Lightning Creek flat, L. Bolduc and L. Blanc are working a lease. The section of the unconsolidated deposits is not very well exposed owing to sloughing of the bank, but appears to consist of boulder clay overlying a stratum of gravel which in turn overlies stratified silt, clay, and sand. The total thickness of the unconsolidated deposits is about 100 feet. A narrow streak of weathered gravel carrying gold is reported to overlie bedrock. The gold is coarse and flat; nuggets worth $1 are common, a few worth more than $10 have been found.

DONOVAN CREEK

(*See also* B.C. Minister of Mines Annual Reports, 1926, 1927, 1931, 1932)

Donovan Creek is a small stream and enters Lightning Creek from the south about 6 miles below Stanley. Two leases near the head of the creek are owned and are being worked by M. Sundberg. A pit with a rim of bedrock on the western side of it was formerly worked. This pit ran out of pay towards its head, but beyond the bedrock rim to the west prospecting revealed a higher run of gold, and this has been followed towards the head of the creek. It is apparent that the bedrock grade increases materially towards the head of the pit. In the pit now being worked, slabs of bedrock rest at various angles to the bedrock with gravel between and beneath them. On the western side of the pit near its head there is a section of 12 feet of gravel which is not cut to bedrock at this point, overlain by about 30 feet of boulder clay. The gravel is roughly stratified, with a slight dip to the west. The greater part of the pebbles and boulders are of the local rocks, and the gravel is well cemented, presumably with a lime cement from the limy beds of the schist in the vicinity. It is reported that the gold is coarse and that one nugget weighing about an ounce has been found.

PETERS CREEK

(*See also* Johnston, 4, pages 177-181, and Annual Reports of B.C. Minister of Mines)

Peters Creek enters Lightning Creek from the southeast about three-quarters of a mile below Beaver Pass House. The creek has been described in detail by Johnston.

Several tributaries of the upper part of Peters Creek are reported to have yielded gold. Few particulars as to the work done could be obtained. At the mouth of Carruthers Creek a pit has been excavated to bedrock, consisting of hard, blocky quartzite. Overlying the bedrock is a mixture of rock detritus and gravel, 4 to 6 feet thick, which in turn is overlain by boulder clay. On the east side of the creek there is evidence of a deeper channel having been worked many years ago. Campbell Creek is another tributary that has produced considerable gold, and a long tunnel is now being driven from the creek westward.

WORMWOLD CREEK

(*See also* B.C. Minister of Mines, Annual Reports, 1907, 1908, 1909, 1911)

Wormwold Creek is a small stream entering Lightning Creek a short distance below the mouth of Peters Creek. The valley is narrow and steep-sided and the lower part at least is floored with glacial deposits. A road in a poor state of repair leads from the Peters Creek road to the old shaft of the Wormwold Creek Mining Company.

Very little information is available as to the mining of Wormwold Creek and for the following information the writer is indebted to H. J. Gardiner, formerly of Beaver Pass, and to the reports of the B.C. Minister of Mines cited above.

The main attempt to mine the deep channel of the creek was made by the Wormwold Creek Mining Company in 1907, 1908, and 1909. This company endeavoured in 1907 to sink a shaft to bedrock a short distance below the forks of the creek. Owing to the quantity of water encountered this shaft was abandoned after reaching a depth of 85 feet. A second shaft was then sunk 135 feet to bedrock, and several short drives run from it, but the expected deep channel was not encountered. A tunnel was, therefore, started on the west fork of the creek, and was run some 290 feet.

Gold may be concentrated along Wormwold Valley, more particularly in its branches, where the valleys are narrow and steep-sided, and concentrations of gold on bedrock are likely to have suffered a minimum of disturbance by glaciation. There is no information as to how deep the superficial deposits are along this section, but it is not thought likely that the deep ground encountered by the Wormwold Creek Mining Company would extend very far up either fork.

LOVETT CREEK

Lovett Creek Valley is a short gulch with a steep grade entering Lightning Creek about 4 miles below Beaver Pass House. Mr. John Strang is ground-sluicing on two leases on the creek. Bedrock was not exposed in the cut, but large slabs of bedrock inclined at various angles lie in the lower gravels with gravel packed between and beneath them. The lower gravels consist largely of angular fragments of the bedrock with a clayey matrix. These are overlain by a couple of feet of stratified clay, dipping steeply downstream, which is in turn overlain by boulder clay. The boulder clay, as exposed, varies in thickness from 15 to 50 feet. Mr. Strang reports that the lower gravels contain very good pay, and that the gold is coarse and very little worn. There is also reported to be a pay-streak on top of the boulder clay. The water available for sluicing is limited and the owner makes use of an automatic dam.

Lower down on the creek it is reported that in 1895, or about that time, a tunnel was driven from the Lightning Creek flat into the west bank of the creek. From the tunnel a shaft was sunk to bedrock, but the expected old channel was not encountered.

PINEGROVE CREEK

Pinegrove Creek is a small stream entering Lightning Creek from the northwest somewhat over a mile above Wingdam. The lower part of the valley is moderately wide, but about a mile from Lightning Creek the creek splits into several forks, the valleys of which rise steeply to the level of the upland surface.

J. Colley is working four leases on the creek just below the forks. A long cut has been run for a considerable distance up the creek and bedrock shows at several points along it. Where exposed the bedrock consists of schist, with seams of talcose material carrying iron pyrite. The cut was made in 1932 and Mr. Colley reports that he recovered some $300 in gold. This season (1933) a somewhat deeper cut is being driven at the upper end of the long cut, but when seen was not down to bedrock. The lower strata, of which about 8 to 10 feet are exposed, consists largely of angular material in a clay matrix. Overlying this is stratified clay from 4 to 6 feet thick overlain by 15 to 20 feet of boulder clay. The gold seen was fairly coarse, and mostly quite rough. A second cut on the east side of the creek is in boulder clay.

BEAVERPASS CREEK

Beaverpass Creek is a small stream about 4 miles long, flowing through a flat, swampy valley with a hardly perceptible grade to Lightning Creek at Beaver Pass House. As already stated, it is generally assumed that Lightning Creek at one time turned to the northwest near Beaver Pass House and flowed through Beaverpass Creek Valley to Willow River.

The chief interest in Beaverpass Creek at the present time lies in the benches. A number of bench leases have been staked along the valley from Lightning Creek well down Tregillus Creek. Of these leases a considerable number have been staked or acquired by Messrs. Langford and Stevens, who have done a considerable amount of preliminary testing work. A topographic map on a large scale has been prepared by them and it shows that the surfaces of the benches have a general grade of roughly 15 feet to the mile, sloping downwards from Lightning Creek towards Willow River. At Baldhead Creek commercial values are reported, and the syndicate is now sinking pits and conducting drilling to test the values of the gravels at points on benches away from tributary streams, because it is considered possible that local enrichment or reconcentration has been effected by these streams. The object of the work is to determine whether the yardage of gravel of commercial grade is sufficient to justify the installation of an extensive water system for hydraulicking.

The discovery at the mouth of Baldhead Creek was prospected early in the summer of 1933 by means of an hydraulic cut. The cut is near the site of an old tunnel on the south side of Baldhead Creek. The lower part of the cut is not on bedrock but bedrock appears in the middle part of the cut and from there rises steeply towards the face. The lower gravels are rusty, vary from fine to coarse, and contain numerous foreign boulders, some of which show glacial striations. These gravels are well cemented with limonite and are about 25 feet thick. They are overlain by 6 feet of uncemented sand and finer gravel, in turn overlain by boulder clay. Towards the face of the pit the lower stratum of coarse gravel is missing, and bedrock is overlain by stratified silt with gravel lenses. The gold is reported to occur in both the lower gravels and in the finer gravels overlying them. It is coarse and flat, and mostly quite well worn, but many of the grains are iron-stained. Some gold believed to come from the glacial deposits above is quite bright.

The deposit is quite evidently of interglacial age. The presence in the lower gravels of several rock types that must have been transported many miles, together with glacially striated stones, points to the erosion of a pre-existing boulder clay as their source. This evidence, and the grade of the benches, indicates that during an interglacial stage Lightning Creek flowed by way of Beaver Pass to Willow River, and, therefore, it would appear that remnants of this channel are to be expected at points along the benches.

Tributaries to Beaverpass Creek

The principal tributaries to Beaverpass Creek are Twomile or China and Baldhead Creeks entering from the east, and No-Name Creek entering from the west. These creeks enter the main valley with fairly steep gradients, but above their mouths a long stretch of each creek is fairly flat. Several of the creeks have been worked for placer gold close to their points of entry into the main valley, but, so far as the writer is aware, no gold has been reported from their upper parts. The gravels worked are in nearly all cases post-Glacial. On No-Name Creek a cut 150 feet long by 10 to 12 feet wide and varying from 4 to 10 feet deep has been made on the lower part of the creek. At the deepest part of the cut the section from top to bottom is as follows: 5 feet of fine gravel mixed with a number of rounded and angular boulders; 1 foot of clay with occasional pebbles; and 3 to 4 feet of gravel. Bedrock is not exposed. It is probable that the deposit was worked to a false bedrock of glacial materials. The number of foreign boulders makes it apparent that the deposit is the result of reworking of boulder clay.

It is reported that no gold has been taken from Baldhead Creek above the Stevens-Langford workings.

TREGILLUS CREEK

Tregillus Creek heads with Beaverpass Creek and flows towards Willow River. The divide between the two creeks is very low. The valley of Tregillus Creek along most of its length is moderately wide and is bordered by benches whose elevation above the stream increases as the valley is descended. About opposite the mouth of Aura Fina Creek, the valley is divided into two parts by a low, rocky ridge about 1 mile long. The northern part is followed by the present stream.

So far as the writer is aware, mining on Tregillus Creek has been limited to work on the benches, and this work has been mostly limited to the taking out of deposits of gold in surface gravels. Such workings are situated on the east side of the valley opposite the mouth of Hyde Creek where the workings occupy a considerable area. The gold, according to information received, occurred in a thin stratum of gravel on top of the bench, the stratum being about 6 feet thick near the front of the bench, but thinning rapidly away from that point. It is reported that the deposit was fairly rich, five men averaging $7 a day while working it. A considerable part of the gravel was handled in wheelbarrows to the main stream to be washed, but the deposit was also worked in part by sluicing. At the upper end of the diggings a shaft was put down 35 feet by W. C. Slade, who states that the shaft did not reach bedrock and that the gold was entirely superficial.

A somewhat similar deposit occurs on the south side of the valley about opposite the mouth of Aura Fina Creek. Here the surface gravels have been worked to a depth of about 6 feet over a considerable area; the material being trammed to the main creek for washing. During the past summer prospectors working on this ground discovered on the bench a paystreak lying not far above the level of Tregillus Creek. Work had not progressed to the point where it could be determined whether this represents a second paystreak at a different level, or is merely a surface deposit formed at a lower elevation. Very good prospects were obtained at this point, part of the deposit going 25 cents to the pan.

On the western side of Tregillus Creek a number of cuts have been made below the mouth of Slade Creek. These workings are on a bench about 100 feet above the level of Tregillus Creek. The workings nearest Slade Creek were excavated by W. C. Slade, who informed the writer that the gold deposits were superficial and quite rich, but that when he attempted to wash off all the material overlying bedrock the results were disappointing. Some 500 feet downstream, and slightly lower in elevation, is a second pit. Here an area of considerable size has been sluiced off to bedrock. Owing to sloughing of the sides of the pit, and the growth of vegetation since the pit was excavated, it was impossible to obtain a section. Other pits between the two workings have been hydraulicked.

The superficial deposits of gold occurring on the benches is believed by the writer to be a result of stream erosion of the glacial deposits whereby they were cut down to the present level. Such deposits do not mark the site of old channel deposits below.

The important tributaries of Tregillus Creek are Lake and Rouchon Creek on the east side, and Aura Fina, Hyde, Slade, and Kee Kahn Creeks on the west. On Kee Kahn Creek about a quarter of a mile from the main valley, a cut has been made by E. M. Falck. The material consists of fine creek gravel, with occasional large boulders, resting on clay. Similar conditions are reported by Lay (2, 1932) to occur on the lease of E. M. Falck on Lake Creek.

ROUCHON CREEK

Rouchon Creek is the only important stream entering Tregillus Creek from the eastern side. The upper part of the creek flows in a valley floored with glacial deposits and, so far as the writer is aware, has not afforded gold. The depth to bedrock in this part of the valley is not known, and no rock outcrops were observed along the valley sides. Near Tregillus Creek, the creek lies in a deep rock canyon, below which it flows in a narrow valley bordered in places by benches. This narrow part of the valley is one-half to three-quarters mile long and extends to Tregillus Creek. Only the part of the creek from the canyon downstream has proved productive. The amount of gold recovered is not definitely known. The B.C. Minister of Mines reports give the production of Rouchon Creek and vicinity to 1895 as approximately $49,000, but it is not known what part of this came from Rouchon Creek itself. Most of the gold has been derived from workings in the stream bed and probably represents a post-Glacial concentration, either of gold held in glacial deposits that have been destroyed in the cutting of the creek to its present level, or of gold reconcentrated from a pre-Glacial channel.

The only work now in progress is being carried on by T. Fry in Larsen Gulch, a small tributary that enters immediately below the canyon. An old tunnel driven through the rim rock exposed at the bottom of the canyon is reported to have passed through the rock and out into gravel and stratified silts. Mr. Fry started ground-sluicing on Larsen Gulch in an attempt to reach the old channel believed to lie on the eastern side of Rouchon Creek and to extend downstream from the head of the canyon. Near the lower end of the cut a rim of rock was encountered whose surface slopes away from Rouchon Creek and thus is evidence of deeper ground beyond. A depression floored with glacial deposits extends from here upstream. It lies east of the canyon and joins Rouchon Creek above it.

Because of the sloughing of the sides of the pit, no section of the unconsolidated deposits could be obtained, but apparently stratified silts (slum) lie on bedrock and are overlain by boulder clay, but the thicknesses of the strata could not be obtained. In one or two places in the pit it appeared as if gravel might underlie the silt, but the presence of gravel was not verified. It appears to be quite probable that an old channel exists at this point, but its depth is unknown. It is probable, however, that the bedrock surface is as low as the bed of Rouchon Creek.

AURA FINA CREEK

Aura Fina Creek is one of the more important tributaries entering Tregillus Creek from the northwest. Its upper part lies in a broad, swampy valley. All the gold produced from the creek is reported to have come from the lower $1\frac{1}{2}$ to 2 miles, where the creek flows through three successive canyons separated by stretches of narrow valley.

According to reports Aura Fina Creek was worked in the early days of the Cariboo, first of all by white men, and later by Chinese. The creek is reported to have been very rich, but there are no data available on the output of gold. The richest part of the creek is reported to have been that between the lower two canyons. The bedrock was followed from the lower canyon upstream until it lay too deep, above that the early workings were not on bedrock. There is, therefore, according to reports, a stretch between the first and second canyons which has not been worked to bedrock. There have also been workings on the low benches on the northeast side of the creek.

HYDE CREEK

Hyde Creek is a fair-sized tributary joining Tregillus Creek about a mile above Aura Fina Creek. As is the case with most tributaries to Tregillus Creek the upper part of the creek is in a broad valley, from which it descends to Tregillus Creek through a canyon. Benches of silt and sand front Tregillus Creek and benches continue up Hyde Creek to the canyon. H. S. Cameron has been prospecting the benches on the sides of the creek, and has put in several cuts now partly sloughed. One of these cuts is about 50 feet long and is on the southwest side of the creek. Mr. Cameron states that coarse gravel was obtained near the bottom of the cut. It is overlain by fine sand and gravel, which in turn is overlain by boulder clay. Coarse colours were reported from the lower gravels. There are several other cuts a short distance downstream, and bedrock outcrops from the lowest to the mouth of the canyon. Mr. Cameron believes that the old high channel along Tregillus Creek cuts across Hyde Creek at this point, but there has not been sufficient work done to test this theory.

SLADE CREEK

Slade Creek is a small stream which enters Tregillus Creek about three-quarters mile above Hyde Creek. Like the other tributaries to Tregillus Creek it enters through a canyon that extends back less than a mile from its mouth. Above the canyon the valley opens, and is reported to be unprospected. Apparently the bed of the stream, as far as the head of the canyon, was extensively worked in the early days, but there is now little information available regarding this work. The only recent work observed on the creek is a cut near the head of the canyon, and the deposit worked is quite evidently the post-Glacial creek deposit.

BERRY CREEK

Berry Creek is a small stream flowing east to Willow River and joining it about a mile below the mouth of Tregillus Creek.

In the bench overlooking Willow River a pit has been sluiced off for a length of approximately 500 feet. In the lower end of the pit bedrock is not exposed and the section consists of stratified clay and silt with bands of gravel. About 150 feet along the pit, 8 to 10 feet of boulder clay is exposed. This is overlain by 8 feet of coarse stream gravel with many large boulders, some of which are 3 feet in diameter. The coarse gravel is overlain by 4 feet of finer gravel, also with some large boulders in it. Bedrock is exposed about 100 feet from the face of the cut, toward which it rises steeply. The material overlying the rock consists of fine gravel and probably corresponds to the upper stratum in the section given above. The work is reported to have been done by E. Rask, and it was also reported that the gold obtained was coarse and rough, with some pieces reaching a value of $5. Some of the gold is reported to have had quartz adhering to it.

VALLEY CREEK

Valley Creek is in the northern part of the area mapped and is reached by means of a road that leads from the Quesnel-Barkerville road, past Eightmile Lake to the mouth of Stewart Creek. This road is 7 miles long and the part beyond Eightmile Lake is in rather a poor state of repair. From the end of the road a trail leads down Valley Creek to West Pass Creek and Stony Lake. This creek has been fully described by Johnston (4) (*See also* B.C. Minister of Mines Reports for 1896, 1913, and 1926).

Attempts have been made by sinking shafts and by drilling to explore the deep channel of Valley Creek, but they were unsuccessful in finding it. It is difficult to see why the deep channel should be expected to carry large amounts of coarse gold. The rocks traversed by the creek and its more important tributaries for the greater part of their lengths, more particularly the upper stretches of the creek, have not been definitely proved to be gold-bearing. They belong to the Slide Mountain series thought by Uglow (4, page 191) to have been deposited after the formation of the gold-bearing veins believed responsible for the placer gold of Barkerville area. Such concentrations of gold as may exist are, therefore, probably the result of the reconcentration of gold moved from elsewhere. The most effective agent for moving coarse gold was the ice-sheet, and it follows that although gold is to be expected in interglacial and post-Glacial deposits in this vicinity, it does not appear likely that large or important deposits are to be expected in the pre-Glacial channel. Coarse gold has been found in the workings of the Big Valley Creek Gold Mines and on Stewart Creek, but there is no evidence to show that these workings were in the pre-Glacial channel.

STEWART CREEK

Stewart Creek is one of the important tributaries to the upper part of Valley Creek, which it joins about 3 miles below Ninemile Lake. The lower part of Stewart Creek is in a rock canyon. Near the head of the canyon, on the south side of the stream, is a placer pit, evidently excavated years ago. Near the head of the pit are some shallow workings where bedrock is exposed and gravel ranging up to 6 feet in thickness has been worked over a considerable area. The pit has been excavated largely in boulder clay.

Three shafts have been put down on the creek between the canyon and the forks. According to the Minister of Mines reports these workings were apparently made between 1896 and 1900. Good pay was reported at that time by the operators.

Stewart Creek like Valley Creek is one that cuts rocks not definitely proved to be gold-bearing.

COFFEE CREEK

Coffee Creek is a small tributary to Valley Creek, entering it about half a mile above the mouth of Stewart Creek. A short distance up the creek from the Valley Creek flat a pit has been excavated on the left side of the creek. The creek here flows over a rim of rock, and the work was evidently done in the expectation of finding an old channel to the south of this rock rim. As far as could be made out from the poor exposures, the workings were almost entirely in boulder clay. The cut follows the rock rim. It is reported that this work was done by the Thistle Gold Mining Company, which also operated at Eightmile Lake.

SUGAR CREEK

Sugar Creek is one of the important southern tributaries of Valley Creek. The upper part of the valley is rather narrow and deeply cut, and the creek descends through a series of rock canyons that occur at intervals throughout its length. The creek was apparently extensively mined in the early days, but figures as to production are not available. In the B.C. Minister of Mines reports from 1881 to 1895, Sugar and Hardscrabble Creeks and vicinity are credited with the production of $68,000. That part of the creek that has been most worked lies between the lower and middle canyons. Over at least part of this stretch the depth to bedrock did not exceed 8 to 10 feet, and from the old workings it is judged that no deep channel was found. Bowman (1), who shows the deep channels of the different creeks on his creek maps, shows no such channel for Sugar Creek.

Along the stretch that has been extensively mined there are remnants of a low rock bench a few feet above creek level. These also have been worked. The only recent work observed is a cut near the head of the lower canyon. It is in the bed of the creek and appears to be in the post-glacial material of the creek. The gravel is fairly coarse and contains many large boulders, which probably came from the erosion of boulder clay.

The lower part of Sugar Creek lies in a deeply cut rock canyon. It seems probable that this is, in part at least, a post-Glacial cutting and that a buried channel lies to one side or the other.

COOPER CREEK

Cooper Creek is a small gulch entering Sugar Creek from the west near the site of Walker House. The valley throughout is narrow and steep-sided. The lower part of the creek lies in a rock canyon. Small rock benches have been worked in this section, apparently many years ago. The bed of the creek has also been worked along this stretch. The creek forks about half a mile above its mouth, and on the west fork, a short distance above the forks, is an hydraulic pit. The pit shows stratified sand and gravel with coarse wash lying beneath. Several streaks of rusty gravels appear in the face. The lower part of the cut is covered by sloughing. An extensive ditch-line was put in from the south fork of Cooper Creek and from Stevens Gulch.

LITTLE MUSTANG CREEK

Little Mustang Creek is a small stream entering Sugar Creek a short distance below Walker House. The valley is moderately wide with very little grade and heads in a swampy pass that marks the divide between this creek and Mustang Creek. The valley of the creek is floored with glacial deposits and has not been worked for gold except near its head and near its junction with Sugar Creek.

Near the junction with Sugar Creek several drifts have been run into a gravel ridge that separates the two creeks. On the Sugar Creek side a rock rim is exposed which possibly is one rim of a former channel of Sugar Creek. The drifts were run as inclines, and no definite information is available with regard to them, although it is reported that they did not reach bedrock.

Near the head of the creek extensive sluicing has been done on a small tributary entering the valley from the south. The sides of the pit were sloughed, so that no section could be obtained other than to ascertain that the upper material is boulder clay.

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THE NICKEL-BEARING ROCKS NEAR CHOATE, BRITISH COLUMBIA

By W. E. Cockfield and J. F. Walker

CONTENTS

INTRODUCTION

A short time at the close of the 1933 field season was devoted to a study of the geology in the vicinity of the nickel deposits situated near Choate, B.C., and owned by B.C. Nickel Mines, Limited. Attention was chiefly paid to the mapping of the rocks in the vicinity of the deposits. Owing to a very heavy fall of snow this work was not completed and the present report is, therefore, only a preliminary statement.

Prospecting work on the property has been in progress from the date of discovery in 1923 until 1931. It is reported that a recent reorganization of the company has resulted in affording sufficient capital to permit prospecting and development on a somewhat more extensive scale.

The writers wish to acknowledge their indebtedness to Mr. C. B. North, engineer in charge, for facilities put at their disposal and information afforded during the course of the work. The information included a map indicating the locations of many of the rock outcrops, particularly along the line of a proposed development tunnel.

The deposits were described by C. E. Cairnes (1, 1924) of the Geological Survey shortly after their discovery, and descriptions have appeared from time to time in the reports of the B.C. Minister of Mines (2). Since the date of the examination by Cairnes considerable stripping has been done, some of the deposits have been partly drilled, and an electrical survey has been made of part of the property, so that much more information is now available.

The deposits are on the ridge between Emory and Texas Creeks, outcroppings of ore occurring on both slopes. A former route to the property was by way of a pack trail up Emory Creek. This route was somewhat long and circuitous and, therefore, in the autumn of 1933 the building of a road up Texas Creek from near Choate Siding on the Canadian Pacific Railway was commenced. It is reported to have been recently completed. Choate is slightly over 100 miles from Vancouver. The road leads from the provincial highway to the site of the proposed development tunnel and camp site, and will be about 7 miles long and have a grade of about 10 per cent.

GENERAL GEOLOGY

The rocks in the vicinity of the ore deposits (*See* Figure 4) belong to three groups. The oldest group consists of schistose rocks that form a prominent hillock on the summit of the ridge. Small inclusions of similar rocks were observed at numerous points in the batholithic rocks. The schists probably represent sediments but have been altered and partly replaced by the later intrusives.

The second rock group is composed of pyroxenitic hornblendite. The hornblendite is generally coarsely crystalline, grey to greenish black, and forms an irregular band that was traced across the summit between Emory and Texas Creeks, and for a considerable distance southeast down Texas Creek. It has also been reported to occur across Emory Creek and across Texas Creek. Under the microscope the rock is seen to vary from a facies consisting completely of hornblende to one in which pyroxene makes up most of the rock. The latter facies was seen only in connexion with some of the mineral deposits. In general hornblende is the most abundant mineral. Feldspar is usually absent, but in those few sections where it was found it is limited to a few grains or individuals, and is plagioclase which could not be definitely determined but appeared to be similar to that of the diorite and, therefore, may be andesine. The pyroxene is mostly orthorhombic, and is mostly hypersthene but in some sections is enstatite. A few of the sections contain small amounts of augite, and nearly all contain sulphides and magnetite, or, more probably, chromite. Where sulphides make up any considerable part of the rock, they are distinctly later than the ferromagnesian minerals.

The third group of rocks are diorites. These vary somewhat in texture and also in colour, depending on the content of ferromagnesian mineral. They are typically grey, medium-grained rocks, and occur in two belts, one to the north and the other to the south of the hornblendite mass. In addition, small areas occur within the hornblendite body. Microscopic examination shows that these rocks consist principally of andesine and hornblende. Pyroxene and biotite also occur, as well as small amounts of apatite, epidote, magnetite, and sulphides (pyrrhotite?). The quartz content does not exceed 5 per cent in any of the sections, and in most of them is much less than 5 per cent. In some specimens none at all was found. Orthoclase feldspar was not identified and is probably absent. The percentage of ferromagnesian minerals varies considerably from specimen to specimen.

In the specimens selected for examination from the diorite north of the hornblendite mass no pyroxene was found, whereas in the specimens of the diorite south of the basic mass pyroxene is an important constituent and appeared in every section. The pyroxene is mostly orthorhombic, and is generally hypersthene, but, as in the case of the hornblendites, some is enstatite. In some sections augite appears but is not plentiful. The

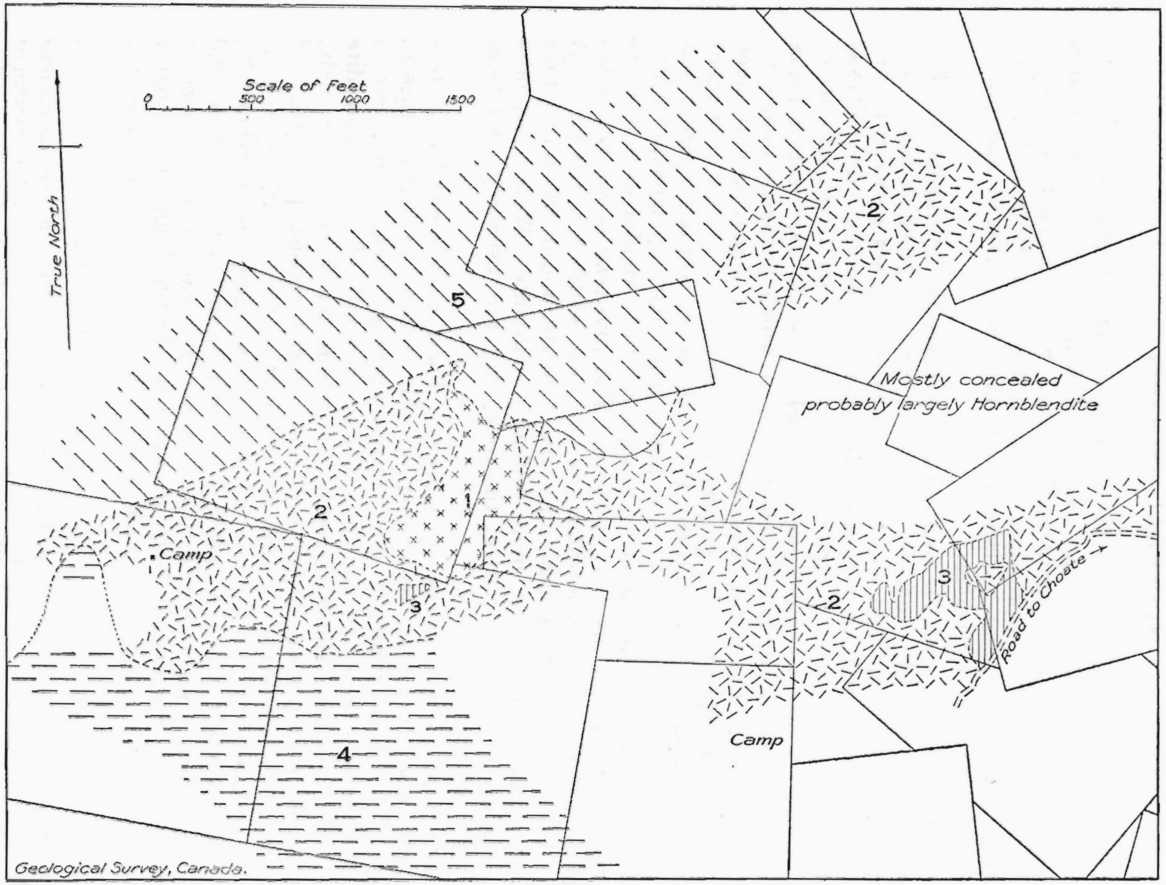

Figure 4. Vicinity of the nickel-bearing deposits near Choate, Yale district, British Columbia. Area of schist (sedimentary?) shown by pattern of crosses (1); areas of hornblendite by irregular dashes (2); areas of diorite in which the presence or absence of hypersthene has not been determined, by vertical ruling (3); area of hypersthene-bearing diorite by horizontal broken ruling (4); and area of diorite lacking hypersthene by sloped broken ruling (5).

diorites to the south, therefore, show a striking relationship to the hornblendites, since both groups carry the same minerals although in different proportions.

The contact of the hornblendite with the diorite follows a highly irregular course which is not suggestive of the form of a dyke. The contact is exposed for any considerable distance at only one place. This is on the Texas Creek slope. Along this contact the diorite holds fragments of the hornblendite, and similar inclusions occur in the diorite away from the contact. In some of the hornblendite inclusions are small masses of the crystalline schists. The large mass of crystalline schist on the summit of the ridge is also in the basic rock. The diorite in contact with some of the hornblende inclusions is somewhat richer in ferromagnesian minerals than the normal phase, and is also somewhat finer grained than normal although not exhibiting a true chilled edge. In the basic rock at points near the contact are seams of diorite which are interpreted as tongues from the diorite mass. For these reasons it is believed that the diorite intrudes the hornblendite. It is true that areas of diorite occur partly or wholly surrounded by hornblendite. The contacts of these could not be seen, but it is believed that such areas represent tongues of diorite projecting from beneath. The writers are of the opinion that the hornblendite is an earlier differentiate of the magma that later produced the diorite, and that this earlier differentiate was injected into the roof rocks forming a mass that was later invaded by the diorite.

The contact of the pyroxene-bearing diorite with the hornblendite was not seen, except at one point where the relationship was obscure. At this point the contact appears to be gradational, but the pyroxene-bearing diorite also contains inclusions of the basic rocks. The relationship of the two phases of the diorite could not be determined in the area examined because the two bodies are separated by the hornblendite.

MINERAL DEPOSITS

The mineral deposits consist of disseminations of sulphide in the hornblendite. A number of showings have been opened, more or less along a line from the old camp to the proposed site of the tunnel. Other showings have been found a considerable distance to the east, and it is expected that others will be found as more careful prospecting is done. Most of the showings have been partly stripped but not enough to fully expose them. Diamond drilling has been done on several, and these have also had their shape outlined by electrical methods of prospecting. It is believed that the showings so outlined have an elliptical shape, with their longer axes trending northwest-southeast across the general strike of the hornblendite, and it appears likely that this trend is followed by some of the other showings which have not been so well explored.

The outcrop known as the main showing is the best exposed. This occurs as a bluff some 30 feet high, situated on the Emory Creek slope about half-way between the old camp and the summit. This has been stripped along the base of the bluff for about 80 feet in the direction of the long axis of the deposit. The deposit is believed to be roughly 200 feet long by 140 feet wide. Where exposed it consists of bands of massive sulphides with leaner bands of disseminated sulphides. Pyroxene appears in the rock with the sulphides. The deposit is cut by a number of strong fractures striking north 20 degrees east. Above the bluff, the deposit is surrounded by a coarsely crystalline, hornblendic phase of the basic rock; the relations on the other side of the bluff are not shown.

Near the level of the old camp on the Emory Creek slope are other showings, one of which was found by electrical prospecting methods. The cuts on these are largely sloughed, so that the relations could not be seen, but the mineralization is similar to that of the main showing. A further showing of disseminated sulphides occurs in the creek bed immediately below the old camp.

On the Texas Creek slope one showing on the Molly claim has been stripped for a considerable length and several showings occur on the Nickel Star. These were not examined in detail.

The ores were not sampled by the writers. A large number of samples have been taken in the course of development work and diamond drilling. Both the copper and nickel content vary from point to point. The copper content of the individual showings varies from about $\frac{1}{3}$ to $1\frac{1}{3}$ per cent and that of nickel from about $\frac{1}{2}$ to $2\frac{1}{2}$ per cent. The more massive bands of sulphides contain, of course, considerably higher values than the above. The chromium content does not appear to vary directly with either the copper or the nickel and in most of the showings is between 1 and 2 per cent. The gold and silver values are low.

Pyrrhotite is by far the most abundant sulphide, and is followed in order by pentlandite and chalcopyrite. The only other metalliferous minerals are, probably, chromite, and, possibly, some magnetite. A mineral secondary after pentlandite and one secondary after pyrrhotite were reported by Cairnes, but not positively identified. These were also seen by the writers but were not identified.

Chalcopyrite is fairly uncommon. Specimens may be obtained in which this mineral is plentiful, but in general it occurs only as occasional grains. The pentlandite cannot be distinguished readily from the pyrrhotite in hand specimens; in polished sections, however, it may be readily identified. One mineral found in the polished sections is believed to be chromite. It appears as small grains, mostly associated with and included in the hypersthene. Occasionally it occurs at the edges of the hypersthene individuals or even included within the sulphides. It is isotropic and gives negative tests with the reagents commonly used. It thus corresponds to chromite and the chromium content of the ore suggests that the identification is correct.

The mineral believed to be chromite was the first to crystallize and it formed mostly before the hypersthene. Of the sulphides pentlandite was the first to form. It is included in both the pyrrhotite and chalcopyrite, and in some cases appears to have been corroded by them. The pyrrhotite and chalcopyrite appear as more or less contemporaneous, for they vein each other. Cairnes (1) has already discussed the secondary minerals and no further discussion of these is necessary.

The question of genesis of the deposits was discussed by Cairnes, who stated he believed that the mineralization was magmatic and genetically connected with the injection of the hornblendite. The further opening up of the deposits has afforded additional evidence which may have some bearing on theories as to origin. The presence of inclusions of the hornblendite in the diorite near the contact of the two rocks makes it appear that the diorite is the later of the two intrusives. All the sulphide bodies seen by the writers occur close to areas of diorite and are not confined to one edge of the hornblendite. There would thus appear to be a close connexion between the diorite and the ore-bodies. But if the diorite is intrusive into the hornblendite the connexion is not one of concentration close to the base of the hornblendite body. Moreover, as far as shown by present development work, the mineral bodies appear to be elliptical in shape with their longer axes generally oriented crossing the trend of the hornblendite, and in the better known cases at least their orientation appears to be along a definite direction, trending northwest and southeast. This is suggestive of structural control such as fracturing, shearing, or jointing.

The sulphides occur in practically all specimens of the hornblendite. Undoubtedly some primary sulphides are present. Cairnes has described corrosion of the hypersthene by the sulphides and ample evidence of this action is offered in the sections studied by the writers. In some sections, however, the hypersthene crystals are cracked and some of the cracks have been penetrated by thin films of sulphides. In the cracks where the sulphides have not been deposited there appears to be a microscopic film of an unidentified secondary mineral and in some cases there appears to be a film of similar material between the sulphides filling cracks and the hypersthene. A second set of cracks filled with quartz also occurs. In general these appear to be later than the sulphides, for in some instances at least they offset the cracks filled with sulphides. Although the fracturing of the hypersthene crystals could possibly have taken place in the magma chamber, it seems more probable it took place after the solidification of the rock. Replacement of the ferromagnesian minerals, more particularly of the hornblende, by sulphides, was noted in several sections. This replacement was seen in various stages: from where the sulphides could be seen as fine lines penetrating cleavage cracks; to later stages where the sulphides replace the interior of the crystals by spreading out from the cleavage planes; and to the stage where the sulphides entirely surround and replace most of the crystal, leaving only a number of isolated cleavage flakes unreplaced. The fact that in the more massive sulphide bodies hypersthene is the predominant gangue mineral, whereas away from the ore-bodies hypersthene is subordinate to hornblende, may possibly be accounted for supposing that the sulphides attacked and replaced the hornblende more readily than the pyroxene. The replacement of the hornblende would thus be more or less complete, whereas the pyroxene would be only slightly affected.

The occurrence of sulphides in the diorite, and of sulphides and quartz in the cracks of the hypersthene of the hornblendite; the replacement of hornblende by sulphides; the fact that all the known bodies of ore occur close to the diorite, either close to the main bodies of diorite or to small tongues of diorite in the hornblendite; and the apparent orientation of the deposits in a definite direction are to the writers suggestive of hydrothermal replacement rather than magmatic segregation. The hypersthene-bearing diorite to the south may be related to the hornblendite, but field work over a larger area is desirable to prove the relationship to the hornblendite and to the diorite to the north. The chromite (?) is regarded as an essential constituent of the rock. Its occurrence with the pyroxene, and the fact that the chrome content does not vary with the copper and nickel content, seem to show that the chrome content differs in origin from the sulphides.

There is a noticeable lack of alteration of the hornblendite and this may be urged as one of the strongest points negativing a theory of hydrothermal replacement. Until further work is done, the writers consider it highly probable that the sulphide deposits are of hydrothermal origin, but agree that this concept has not been definitely proved.

In the development of the deposits definite structural control should be looked for. In certain cases strong fracturing running across the deposits has been definitely noted; in other cases jointing is quite pronounced. The finding of structural control would materially assist in the development of the deposits.

The area has received only a preliminary prospecting. The hornblendite appears to occupy an area of considerable size and can be regarded as very favourable ground for prospecting. A considerable part of this area is covered with surface accumulations, possibly due in part to the ease with which this rock weathers. It is considered almost certain that other deposits will be found in the process of prospecting the area, and the surface prospecting can undoubtedly be aided by the use of electrical methods.

The ore-bodies on which work has been done give promise of being of reasonable size, and the development campaign now in progress should quickly test their continuity in depth.

If, as the writers believe, the diorite is intrusive into the hornblendite it would follow that the basic rock has a limited vertical range as contrasted with the idea of a dyke extending downward without limit so far as mining is concerned. What the vertical range may be is impossible to state. In some places it may be comparatively shallow, as tongues of diorite appear in the hornblendite; in other places, owing to the wide area underlain by the hornblendite, it may be comparatively deep. So far as known at present the mineral deposits are confined to the basic rock.

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LILLOOET MAP-AREA, BRITISH COLUMBIA

By J. F. Walker

CONTENTS

INTRODUCTION

Lillooet map-area embraces an area of 1,520 square miles of rugged, mountainous country between longitudes 122° and 123°, and latitudes 50° 30′ and 51°, and lies west of the town of Lillooet on Fraser River. Geological investigation in the area was initiated by Camsell (1) in 1911 and continued in the following year by Bateman (2), in 1915 by Drysdale (3), and in 1919 and 1920 by McCann, the results of this work appearing in 1922 on the map of Bridge River area and in Memoir 130 by McCann (4). Meantime Camsell (5) traversed the route of the Pacific Great Eastern Railway through the southeast corner of the present map-area, and, later, Dolmage (6) extended the geology of Bridge River map-area northwesterly along Gun Creek. Cockfield (7) revised the geology in the vicinity of the Lorne mine in 1931 and the following year he and the writer (8) extended the revision along Cadwallader Creek.

The past season, 1933, was spent within the confines of Lillooet map-area. Mr. J. Y. Smith rendered efficient assistance in the field. The writer takes this opportunity of expressing his appreciation of assistance rendered by mining men and residents of the district. The present report mainly consists of accounts of several lode gold deposits.

The Pacific Great Eastern Railway traverses the southeast part of the map-area. The only road connected with the trunk highways of the province is one from Lillooet along Bridge River to Moha, and another along Cayoosh Creek to the old Golden Cache mine. A motor road commencing at Bridge River Station on Seton Lake crosses Mission Mountain to Bridge River and continues along it to the Cadwallader Creek mining camp. A road from Pemberton follows the railway to D'Arcy at the south end of Anderson Lake, and another follows Lillooet River to the southwest corner of the map-area. A trail from the latter crosses to Hurley River and follows it to the road at Cadwallader Creek. A trail from Poole Creek Station follows Birkenhead River into the map-area. Numerous trails leading off from the roads and railway render the greater part of the district readily accessible.

The map-area lies on the eastern slopes of the Coast Range Mountains. Bridge River and its tributaries drain the northern and greater part of the area, and this drainage, with the drainage tributary to the Anderson-Seton Lake Valley, is easterly to the Fraser. The Birkenhead and its drainage is southerly to the Lillooet, thence by Harrison Lake to the Fraser. Relief varies from 750 feet at Seton Lake to a maximum of 9,607 feet at Whitecap Mountain, and the average, depending on the depth of the larger valleys, is from 4,000 to 7,000 feet.

GENERAL GEOLOGY

The rocks of the map-area consist of folded, schistose sediments and volcanics trending in general northwesterly and invaded by various types of granite, quartz diorite, etc., forming large and small bodies. The sediments and volcanics range in age from Triassic or older to Tertiary and belong to several series separated by unconformities. Some of the granitic rocks may be older than some of the sedimentary series, but it is not improbable that all are younger.

The hornblende (augite) diorite stocks of the Cadwallader Creek gold camp because of their areal association with the gold-bearing lode deposits have attracted attention. Two stocks of this diorite were examined during the past season. One crosses McGillivray Creek below the forks and the other extends west from Anderson Lake from a point about one-half mile north of D'Arcy.

Quartz diorite forms large bodies in the southwestern part of the map-area. It is younger than all the pre-Tertiary sedimentary and volcanic formations, but is cut by numerous rhyolite, syenite, and lamprophyre dykes. A small stock of miarolitic granite is also younger than the quartz diorite. This stock and some dykes of miarolitic granite outcrop on the shores of Anderson Lake about midway between D'Arcy and McGillivray Falls. The granite is rather finely grained, flesh coloured, and contains numerous cavities. It is cut by rhyolite dykes and others that are lamprophyres or andesites.

MINERAL DEPOSITS

The mineral deposits of Bridge River map-area have been described in previous reports. Lode gold deposits are of prime importance and are the only ones described in the following pages. The chief factor controlling mineralization appears to be the presence of a favourable rock formation competent to maintain fissures. Hornblende diorite, greenstone, and wider belts of cherty quartzite and chert fulfil the requirements of being massive, hard, and brittle. The more favourable sedimentary formations in the region of Anderson and Seton Lakes lie westerly to southwesterly from the hornblende diorite stock crossing McGillivray Creek; particularly about the headwaters of the west fork of McGillivray Creek and the southerly continuation of the formations into the valley of Blackwater Creek. All of the formations in this area are not favourable, but only belts of the harder rocks.

The areas of crushed volcanics and cherts are on the whole not particularly favourable, though within these areas are smaller ones of more favourable greenstone. The serpentine rocks though massive and hard do not fracture well and, therefore, have been looked upon with little favour. Shearing in these rocks is generally accompanied by the production of

Figure 2. Manson River-Slate Creek area. Areas of old placer workings are shown by pattern of stipple; and areas of bedrock outcrop by diagonal ruling; arrows indicate positions of parts of abandoned stream channels cut in present surface and not clearly indicated by contours.

schistose bands through which mineralizing solutions would find difficulty in making their way. Yet it is possible that under certain conditions the serpentines may fracture cleanly.

The producing mines and nearly all the prospects within the map-area lie along a northwesterly trending zone from the south end of Anderson Lake to the northwest corner of the area. In Cadwallader Creek area, quartz, accompanied by a little sericite, and locally by calcite, mariposite, or scheelite, is the chief vein filling material (8). The main metallic minerals are gold, arsenopyrite, pyrite, chalcopyrite, galena, sphalerite, stibnite, tetrahedrite, and a telluride—sylvanite or possibly calaverite. The sulphide minerals are generally in small amounts and pyrite and arsenopyrite are the most abundant.

In the region about Anderson Lake the quartz veins for the most part carry a little sericite, in some instances mariposite, and very little sulphide. Some of the veins are jointed or sheeted, but the thin film of sulphides commonly found along the joint planes of the veins in Cadwallader Creek area is lacking in this area. The quartz is white but slightly glassy and has the appearance of the lower grade quartz in the Pioneer mine.

In the region of Anderson Lake most of the veins closely follow the strike of the country rock. Some show widths up to 40 feet. Most of the veins are reported to be barren or to carry a trace of gold and so far commercial values have seldom been found. The veins are irregular, in some cases are lenticular, in other cases they send out short, ragged offshoots.

NATIONAL MINE

The National mine is the property of National Gold Mines, Limited, and was formerly owned by the Anderson Lake Mining and Milling Company, Limited. The property has also been known as the McGillivray Creek mine and as the Brett mine. The property was staked by F. Brett in 1898 and Thos. Brett, one of the original owners, is in charge of operations. The mine is on the north side of McGillivray Creek, 3½ miles by trail from McGillivray Falls Station on Anderson Lake. The distance in a direct line is only about 1¾ miles.

An irregular quartz vein strikes north, dips at a high angle to the west, and closely follows the strike of the neighbouring carbonaceous phyllites and ankeritic, slaty beds which may be altered tuffs or volcanics. The vein strikes up the slope of a small ridge and outcrops are poor. It has been exposed at the surface by stripping between elevations of 3,640 feet and 3,730 feet, in a pit at 3,800 feet, and, possibly, in a cut on the east side of the ridge at about 3,900 feet elevation.

No. 1 level has caved in and is inaccessible. No. 2 level, at 3,550 feet elevation, exposes the vein for 225 feet north from the portal, beyond which point the working is lagged up for 55 feet to where it is blocked by a cave-in. The vein is 7 feet wide at the portal and maintains this width for 175 feet. At the end of this stretch it narrows and remains so for 15 feet, beyond which it widens. Numerous spurs from the vein give it an irregular appearance.

The portal of No. 3 level is 255 feet south of the portal of No. 2 level and 150 feet lower in elevation. This working follows the vein for

280 feet and then branches. The average width of the vein is about the width of the working or greater. A stope about 30 feet high starts at 40 feet from the portal and is 34 feet long. At 125 feet from the portal a crosscut 25 feet long to the west exposes 5 feet of quartz 3 feet west of the main vein and 3 feet farther west a stringer of quartz. At 146 feet from the portal a small slip displaces the vein a couple of feet to the west. At 185 feet a crosscut to the west, 16 feet long, shows the vein to be not less than 10 feet wide, and 3 feet west of it is another 2 feet of quartz. The northerly branch of the adit commences at 280 feet from the portal. It passes through the west wall of the vein at 20 feet and continues west of the vein for 100 feet farther. The easterly branch follows the vein northeast for 30 feet to a fault striking 350 degrees and dipping 73 degrees west. The vein is exposed immediately beyond the fault and follows a northeasterly course for 50 feet to where it again assumes its northerly course which it follows for 70 feet, but dips steeply to the east. At the end of the 70-foot stretch the vein appears to pinch out, but it appears again beyond an interval of a few feet where it turns easterly and is exposed in a flat-lying fold against a fault which strikes 342 degrees and dips 50 degrees west. This fault is 70 to 80 feet east of the projection of the main part of the vein on this level. Twenty feet east of the fault some quartz is exposed, striking with the formation, and may be the faulted continuation of the vein, but if so it is poorly defined and not as strong. The vein varies greatly in width and the walls are not everywhere well defined. Its width as exposed in No. 3 level averages more than 6 feet.

The vein in No. 2 level and that portion exposed by stripping is west of the 350-degree fault, and all of the workings above No. 3 level are west of the 342-degree fault. Both faults appear to be normal ones with the downthrow to the west. The 350-degree fault has apparently displaced the vein so as to place the segments alongside one another on No. 3 level. The 342-degree fault appears to have a fairly large throw, and if so and if the quartz 20 feet east of it is not the vein then there is little or no evidence by which to estimate the amount of displacement. Every hundred feet of elevation will throw the horizontal trace of this fault plane 80 to 85 feet east or west, depending on whether the elevation is taken above or below the point in consideration.

There is considerable silicification of the wall-rocks along the vein. A little pyrite is practically the only visible sulphide. The values are not known to the writer. Those published in the Reports of the B.C. Minister of Mines indicate low average values with pockets of high-grade ore.

DIORITE GROUP

The Diorite group lies across the steep end of the ridge east of the forks of McGillivray Creek. A small stock of hornblende diorite intrusive into sedimentary and volcanic rocks forms this steep ridge.

The main showing is at an elevation of 4,520 feet, 470 feet above the forks, and toward the eastern side of the stock. Here a quartz vein 15 feet wide strikes north, dips 77 degrees west, and cuts the hornblende diorite. The diorite stock is elongated in a north-south direction, therefore the strike of the vein is along the length of the stock. The hornblende diorite is schistose along the walls of the vein and a green mineral, possibly mariposite, is present in the schistose material along the east wall. A lens of greenish, siliceous schist 18 inches wide occurs in the vein 4 feet from the west wall. Some small cavities were evidently filled with sulphide minerals which have been completely removed. The quartz is white, somewhat watery, and fractured across the width of the vein. There is no film of sulphide, however, in the fractures. The vein is partly exposed 80 feet higher, and Mr. H. H. Sutherland stated that it could be traced beyond. Rock exposures are good above the main showing, but are largely obscured below by talus material. The shearing along the walls of the vein suggests strong fissuring of the hornblende diorite.

A few feet west of the main showing is a small vein 1 to $2\frac{1}{2}$ feet wide of quartz similar to that of the main vein. It strikes 20 to 25 degrees, dips at a high angle west, and should join the main vein a short distance up the hill-side.

Another quartz vein, accompanied by a little pyrite and some tremolite, outcrops about 1,000 feet west of the main showing. It is from 2 to perhaps 4 feet wide, strikes 25 degrees, and dips at a high angle northwest. The quartz is like that in the main showing. It follows what appears to be a well-defined fissure in the hornblende diorite with about 1 foot of clayey gouge on the walls. This vein is close to the west side of the diorite stock.

These veins are reported to carry some values in gold, and, though there is little evidence of sulphide mineralization, they fill what appear to be strong fissures.

GOLD HILL

The Gold Hill group of sixteen claims lies south of McGillivray Creek, both above and below the forks, and extends across the ends of two ridges that rise steeply from the creek with a little valley between them.

A large quartz vein outcrops on the easterly ridge at an elevation of 4,500 feet, or about 450 feet above the forks of McGillivray Creek. The vein strikes 170 degrees up the hill-side and is exposed for 150 feet. Mr. Sutherland, who is in charge of development work, stated that he had traced the vein to a point 500 feet above the lower outcrop. The vein has been crosscut by an adit at shallow depth. The country rock is a grey, argillaceous phyllite, striking 335 to 340 degrees and dipping 70 degrees east. Outcrops are fairly good up the hill-side from the showing, but are scarce down the hill-side toward McGillivray Creek. The western wall of the vein is along a well-defined shear in the phyllite. As exposed in the adit the vein is 30 feet wide, followed by 5 feet of silicified phyllite and another 2 feet of quartz. The east wall of the vein is not as well defined as the west wall. There is considerable jointing in the quartz parallel to the strike of the vein but dipping less steeply to the west. A little pyrite was seen in the quartz and also in the phyllite. The vein in a cut made by ground-sluicing is exposed 50 feet below the adit and 50 feet to the east of its projected strike. It is either faulted or makes a very sharp bend. A lower level has been driven since the writer's visit to the property. It should be a fairly simple matter to trench across the projected strike of the vein at intervals up the hill-side and thus obtain a fairly good idea of its character and worth.

The other showings on the Gold Hill group are on the very steep end of the westerly ridge above the forks. A cut at an elevation of 5,380 feet exposes a well-defined fissure with brownish schistose rock to the west and a light grey, siliceous, pyritized rock to the east. The quartz filling along the fissure is very irregular and varies in width from 4 to 6 feet. The same fissure is exposed in another cut 50 feet lower in elevation. Here the brownish schistose rock is to the east and slaty beds to the west strike 10 degrees and dip 70 degrees east. The shear or fissure closely follows the strike of the formation and the quartz filling forms irregular masses up to 6 or 7 feet in width. The same fissure is exposed again 110 feet lower, cutting brown ankeritic volcanics (?) . The quartz filling is irregular, somewhat rusty, and crushed across widths up to 6 feet.

About 1,000 feet easterly is a well-defined quartz vein, 15 inches to 4 feet wide. It strikes 350 degrees and dips 65 degrees east. It is exposed between elevations of 5,080 feet and 5,280 feet by a number of strippings. It cuts a tongue of granitic rock, probably associated with the quartz diorite stock, a mile to the west. It is well defined and looks more promising than the partly quartz-filled fissure to the west. The steep hill-side renders the prospecting of these veins a comparatively simple matter and their worth should be easily determined by careful sampling.

GRAND SLAM

The Grand Slam group of claims, owned by D. R. McDougall and W. A. Fleming of D'Arcy, is on the southeast side of Blackwater Valley at an elevation of 2,430 feet, or 1,500 feet above the railway and distant 1½ miles from it in a direct line. This is apparently an old location which has been rediscovered. The hill-side is well wooded and outcrops are poor. The main showing is a quartz outcrop about 40 feet in diameter. The south wall appears to strike 315 degrees and to dip vertically. The quartz is white and holds traces of pyrite and limonite. The wall-rock on the south side is altered to a mass of quartz, ankeritic carbonate, and a greenish mineral which may be mariposite. Outcrops of the vein can be traced northwesterly for 860 feet to a point 155 feet higher in elevation. The country rock is poorly exposed and is slightly carbonaceous, phyllite grading to more quartzose phyllite. The vein strikes and dips with the formation and its full width is exposed at only the one place.

BLUE BELL GROUP

The Blue Bell group of claims is at an elevation of 4,300 feet on a ridge east of the south end of Anderson Lake, and was developed about eight years ago by Mineral Mountain Mines, Limited.

The property is close to the southeast edge of a quartz diorite stock, and the sedimentary rocks are everywhere cut by dykes. Mineralization occurs as a pyritization of an irregular, dyke-like intrusive lying in limestone, argillite, and quartzite. The main working is an adit at an elevation of 4,430 feet. It has been driven for 155 feet, in a direction of 117 degrees, to strike the downward extension of an exposure of heavily pyritized dyke (?) rock in contact with limestone 60 feet higher in elevation. The adit entered the pyritized rock at 95 feet and continued in it for

60 feet to the face. Another adit was driven 100 feet lower in elevation for 190 feet in a direction of 122 degrees through argillite, quartzite, and sills without reaching its objective. The prospect was developed as a lead-zinc-silver property, but where minerals containing such values occur is unknown.

MOHA

The property of Moha Mines is situated on lower Bridge River about 18 miles by road from Lillooet.

A small quartz vein outcrops in the rock gorge of the river at stream level on the southwest side. The vein is 6 to 15 inches wide, strikes 340 degrees, dips 88 degrees northeast, and cuts a fractured, andesitic greenstone. It cuts across a point of rock between the present river channel and an older and deeper one to the south which is filled with unconsolidated materials. An adit has been driven a short distance on the vein. At 15 feet from the portal, or about 40 feet along the vein from the river edge, a shallow winze shows the dip of the vein to change at a small slip. It does not appear in the adit beyond the slip. The adit passes out of the rock into gravels at 50 feet from the portal. The foot-wall of the vein breaks free and there is considerable shearing in the greenstone along that side. There is more brecciation in the greenstone along the hanging-wall side and the vein is partly frozen to the wall on that side. Projecting along the strike of the vein across the river has failed to discover its continuation. Somewhat more easterly, however, are a number of small, irregular masses of quartz up to a few feet in length and depth, and a foot wide, but lacking the definition expected in a vein. Some specimens of free gold are obtainable from the vein, and Mr. Geo. L. MacInnes who is interested in the property states that values range from $1.80 to $41.60 across 10 to 22 inches.

winze
50' adit.

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DEEP BORINGS IN BRITISH COLUMBIA

By W. A. Johnston

(Geologist-in-Charge, Division of Pleistocene Geology, Water Supply, and Borings)

Comparatively little drilling for oil, gas, and water in British Columbia was done in 1933, the chief interest being the oil possibilities of the Sage Creek Dome in the southeastern part of Kootenay district, where Columbia Oils, Limited, is drilling a well. The well has reached a depth of 1,350 feet, and is cased with 12½-inch casing to a depth of 1,000 feet. Oil from a shallow horizon that is cased off in the main well is used for firing the boilers. As the Precambrian siliceous dolomites through which the well is being drilled are very hard, it is proposed to use a heavy diamond drill for the lower part of the well, which may exceed 4,000 feet in depth. The area has recently been examined by G. S. Hume who states[1] that

> "The surface structure is a dome in Precambrian strata and if this dome persists to depth into younger rocks below the Precambrian, the prospects for production would appear to be favourable. The oil doubtless originated in these younger rocks and is now escaping through fracture zones in the Precambrian. The depth to the younger rocks under the Precambrian is not known. It does not seem probable that it can be much less than 4,500 feet and may be somewhat more."

Drilling by the Okanagan Oil and Gas Company in Kelowna district is reported to have reached a depth of 2,740 feet. In Fraser Valley the Noble Francis Natural Gas Corporation drilled to a depth of 820 feet near Cloverdale and obtained a small gas flow. The Natural Gas Development Corporation propose to drill a well near the old Boundary Bay Oil Company's No. 1 well in Fraser River Delta, which was drilled a number of years ago, and was reported to have struck a gas flow at 2,300 feet.

[1] Geol. Surv., Canada, Sum. Rept. 1932, pt. B, p 19.

OTHER FIELD WORK

W. H. Miller. Mr. Miller continued a topographical survey on a scale of 4 miles to 1 inch of Carmacks map-area, Yukon (latitudes 62° to 63°, longitudes 136° to 138°).

A. C. Tuttle. Mr. Tuttle continued a topographical survey on a scale of 4 miles to 1 inch of a district in British Columbia, lying between latitudes 55° and 56° and longitudes 124° and 126°. This district embraces the headwaters of Nation and Manson Rivers and upper stretches of Omineca River.

R. Bartlett. Mr. Bartlett commenced a topographical survey on a scale of 1 mile to 1 inch of Willow River map-area, British Columbia (latitudes 53° to 53° 15′, longitudes 121° 30′ to 122°). This map-area includes a part of the area represented on the Barkerville map-sheet.

R. C. McDonald. Mr. McDonald commenced a topographical survey on a scale of 2 miles to 1 inch of Bridge River district, British Columbia (latitudes 50° 30′ to 51°, longitudes 122° to 123°).

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The annual Summary Report of the Geological Survey is issued in parts, referring to particular subjects or districts. This year there are four parts, A, B, C, and D. A review of the work of the Geological Survey for the year forms part of the Annual Report of the Department of Mines.