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

GEOLOGICAL SURVEY
W. H. COLLINS, DIRECTOR

Summary Report 1932, Part A I

CONTENTS

OTTAWA
J. O. PATENAUDE, ACTING KING'S PRINTER
1933

No. 2331

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

GEOLOGICAL SURVEY
W. H. COLLINS, DIRECTOR

Summary Report 1932, Part A I

CONTENTS

OTTAWA
J. O. PATENAUDE, ACTING KING'S PRINTER
1933

No. 2331

PLACER AND VEIN GOLD DEPOSITS OF BARKERVILLE, CARIBOO DISTRICT, BRITISH COLUMBIA

By W. A. Johnston and W. L. Uglow

CONTENTS

Illustrations

INTRODUCTION

This is a summary of a memoir (No. 149) of the same title, by the above-mentioned authors, that was published in 1926 but is now out of print. Discovery of rich ore in the underground workings of the Cariboo Gold Quartz Company, together with the present country-wide activity in gold mining, have created a prospecting boom in and around the Barkerville map-area, and a consequent demand for the map and report. To meet this demand the Barkerville map (No. 2046) has been reprinted. Copies may be obtained on application to the Geological Survey, Ottawa, or its branch office, 508-512 Winch Building, Vancouver. As the original report (Memoir 149) comprises 246 pages and would be slow and expensive to reprint, the present abridged version is provided as a substitute.

No field work has been done in Barkerville map-area by the Geological Survey since 1924, when Johnston and Uglow completed their survey. Consequently, the present summary does not contain information about subsequent mining developments. For these the reader is referred to reports by the provincial Department of Mines. This summary and the reprinted map are intended for prospectors working in the area.

GENERAL GEOLOGY

Barkerville map-area embraces 210 square miles, the village of Barkerville being at about the centre of the area. The solid rocks, consisting of various igneous, sedimentary, and metamorphic types, form ridges and valleys trending northwest and with the associated northeast cross-range structures control the somewhat rectilinear drainage pattern seen on the map. Unconsolidated sediments, of Tertiary, Pleistocene, and Recent times, obscure a considerable part of the bedrock surface, but the general simplicity of regional structure enables the geologist to extrapolate or project rock boundaries beneath the veneer of regolith. The only solid rock formation of determined geological age found in the area is the crinoidal limestone of the Greenberry formation, which is allocated to the Mississippian period. Basic sills and dykes, whose age is tentatively assigned to the Jurassic, are in intrusive contact with the uppermost member of the Slide Mountain series (which includes the Greenberry formation). Below the Slide Mountain series, and separated from it by an unconformity, is the well-known Cariboo series of doubtful age, to the weathering of parts of which the formation of the gold of the placer deposits is attributed.

Table of Formations

Period		Formation		Lithology	Thickness, feet
Quaternary	Recent			Sand, gravel, silt, muck, peat	
	Pleistocene	Glacial		Boulder clay, morainic accumulations, stratified fine sand and silt ("slum"), stratified gravel and bouldery deposits, cemented gravel	
		Interglacial		Soil, gravel, lignite (?), stratified glacial silt, and sand, oxidized gravel	
		Unconformity			
Tertiary				Gravel partly cemented, slide rock	
		Unconformity			
Mesozoic?	Jurassic?	Mount Murray Sills and dykes		Diabase, gabbro, diorite	
		Intrusive contact			
Palæozoic	Mississippian	Slide Mountain series	Antler	Thinly bedded, white, red, and black chert interbedded with greyish green, indurated shale	3,500+
			Waverly	Basic volcanic flows and breccias	2,000±
			Greenberry	Crinoidal limestone	400
			Guyet	Basal conglomerate	900

Table of Formations (Continued)

Unconformity					
		Proserpine sills and dykes		Quartz porphyry, felsite, aplite	
Intrusive contact					
Precambrian(?)		Cariboo series	Pleasant Valley	Slate, phyllite, sericite schist, chlorite schist, schistose volcanic breccia	5,000+
			Barkerville	Limestone, quartzite, micaceous quartzite, slate, sericite schist	2,500
			Richfield	Quartzite, quartz slate, sericite schist, fine-grained conglomerate, black carbonaceous slate	8,000+

CARIBOO SERIES

This series underlies the main part of the placer deposits, and placer gold has not been recovered to any extent outside of its boundaries. It was mapped by Bowman as covering approximately the same area, but the base of his Bear River series was placed low enough to include a part of what is now called the Barkerville formation of the Cariboo series. The series as at present outlined is made up of the Richfield, Barkerville, and Pleasant Valley formations and consists of quartzite, quartz slate, sericite and chlorite schist, slate, limestone, and volcanic breccia. It lies unconformably beneath the Slide Mountain series of Mississippian age. Contemporaneous with its deposition, there was volcanic extrusion, followed by igneous intrusion on a small scale.

Richfield Formation

Partial sections of the formation are well exposed at the following localities: canyon of Antler Creek below Sawmill Flat; canyon near mouth of Stevens Creek; upper Grouse Creek; Bald Mountain Plateau from Proserpine Mountain westerly across the anticline on Mount Agnes to the western part of Elk Mountain; Devils Canyon Creek; Stouts and Lowhee Gulches; tops of Burns and Amador Mountains; and Lightning Creek. It constitutes the main part of what is popularly known as the Cariboo schists; though true schists form only a small element in it. The rocks were originally mainly quartzose sediments, but are now metamorphosed to massive quartzite, fine quartz pebble conglomerate, micaceous quartzite, quartz slate, quartz sericite schist, sericite schist, carbonaceous and clay slate with minor intercalations of limestone, calcareous argillite, and silicified tuff. Massive, thickly bedded, light grey to greyish black quartzite is a striking member. It is characterized by abundant, glassy pebbles of quartz which give the rock a pseudo-porphyritic appearance, and is splendidly exposed in upper Grouse Creek Canyon, along the old Barkerville-Stanley road in the vicinity of Ella Lake, and in the narrow gorge between Burns and Amador Mountains. In all of these localities it breaks down into talus slopes of large, irregularly shaped, dark-coloured fragments. Grading into this quartzite is a more thinly bedded, micaceous variety of pale brown, grey, or white colour and of a more even-grained fabric. The beds vary in thickness from a fraction of an inch to a foot. The bedding planes are characterized by a parallel arrangement of sericite flakes, but within each bed there is no such parallel arrangement, and, consequently, no cleavage. Minute veinlets of quartz traverse the beds in all directions, producing a characteristic network. The prevalent faint brown colour seems to be due to original hematite or limonite cement. Excellent exposures of this member occur on Mount Agnes and Mount Burdett, as well as in the canyons of Stevens and Antler Creeks, above mentioned. Still more thinly bedded varieties of the same rock, representing stages of transition into a sericite schist, are described as quartz slates and quartz-sericite schists. They are distinctly quartzose, as distinguished from the clay slates and schists of the Pleasant Valley formation. Sericite increases in amount in the transition until true schists are formed. These quartz slates, quartz-sericite schists, and sericite schists are dominantly pale brown and very platy. Commonly they are strikingly drag-folded. The brown colour is due partly to the presence of the iron oxides as original cements and partly to the impregnation of the rocks with siderite and ankerite which were subsequently oxidized. These more thinly bedded and schistose varieties of the quartzites originated from argillaceous sandstones or arenaceous shales, and are particularly well exposed just above the big bend on Grouse Creek and in the various creek canyons in the vicinity of Stanley. A few thin bands of black, glistening, carbonaceous, and graphitic slate occur associated with the quartzites. One of the most prominent of these bands occurs along the exposed crest of the anticline and appears at the surface on Mount Burdett, Mount Agnes, and Elk Mountain. Intercalations of fine to medium-grained, grey limestone, greenish grey tuff, and greyish white, calcareous argillite are also found within the Richfield formation.

Barkerville Formation

For the most part this formation is poorly exposed, and its outcrops are largely confined to the gorges of Antler, Beggs, Grouse, Williams, and the lower part of Shepherd Creeks where these cut across the strike, and to some of the steep slopes of the western side of Antler Creek. Typical exposures occur on the Barkerville-Quesnel road immediately north of the town of Barkerville, and on the southerly extension of Waverly Mountain, 2 miles due south of the main peak. The eastern belt of the Barkerville formation was included, on Bowman's map of Cariboo district,[1] with his Bear River series, chiefly on account of the prominent limestone members that the formation contains. As a consequence of this error, Bowman's line of separation between his Cariboo and Bear River series does not correspond with that of the author of this chapter.

The chief rocks are limestones presenting characteristics that vary according to the intensity of their deformation. Typical exposures on the ridge extending southerly from Waverly Mountain are a thickly bedded,

[1]Accompanying Geol. Surv., Canada, Ann. Rept., vol. III, pt. I, pt. C (1889).

fine-grained, massive, grey, unmetamorphosed type, associated with a medium-grained, buff-coloured, crystalline type and with a thinly bedded, argillaceous variety. Where the limestone shows evidences of intense minor folding it is slaty, with the cleavage parallel to the axial planes of the folds. In many places, also, blocks of angular grey limestone are separated by a lighter-coloured filling of coarser-grained calcite. Most of the exposures show networks of veinlets of white calcite ramifying through the grey and buff types. In folding the limestones acted as competent members, and the erosion remnants of them are prominent features of the topography. Associated with and separating the limestones are thinly bedded, sericitic quartzite, quartz slate, and quartz-sericite schist, similar to the corresponding members of the Richfield formation. Clay slate, and phyllite, black to brown in colour, with minor amounts of greenish tuff, also occur and seem to represent transition phases between this and the overlying Pleasant Valley formation.

Pleasant Valley Formation

These rocks conformably overlie the Barkerville formation. They are poorly exposed, except in the gorges of some of the creeks. Excellent sections of parts of the formation may be seen at the junction of Pleasant Valley and Grouse Creeks; in the pit of the New Waverly Hydraulic Mining Company; in Antler Creek near the junction with Quartz Gulch; and particularly along Shepherd Creek and the Downey Pass Creek road.

The members are essentially argillaceous, the dominant type being a clay slate, varying from grey to pale brown to black, and possessing a well-developed cleavage. Other rock types in this formation are: calcareous slate, sericite schist, slate with knots of cordierite, chlorite schist, schistose amygdaloidal metabasalt, schistose basic volcanic flow breccia, greenish schistose tuff, black graphitic slate impregnated with cubes and grains of pyrite and prominently cross-seamed with paper-thin veinlets of pyrite, greyish green, schistose tuff-agglomerate, etc. Veinlets and lenses of quartz occur abundantly throughout the formation, and the oxidation of disseminated pyrite and ankerite or siderite has produced a prominent brownish colour.

PROSERPINE SILLS AND DYKES

A large number of brownish weathering sills and a few dykes cut the various members of the Cariboo series. They are usually not more than a few feet thick, but in two or three places a thickness of 30 or 40 feet was observed. Owing to the covering of glacial drift and vegetation it was impossible to follow them along their strike, except for very short distances. Only a few were indicated on the geological map. They were not found to occur in the Slide Mountain series, but pebbles of a similar lithological character occur in the Guyet basal conglomerate.

All the acidic sills and dykes that cut the Cariboo series have been grouped as the Proserpine intrusives. Quartz porphyry, felsite, aplite, and quartz latite are prevalent types. Their outcrops are characteristically iron-stained, due to the oxidation of disseminated pyrite and siderite. The alteration and oxidation of the sills have in many cases so obscured their petrographic character that it does not afford a clue to their intrusive relations. Contact metamorphism of the adjacent slates and phyllites has produced along their borders an assemblage of knots of cordierite which have been considerably weathered to kaolin and limonite.

A noteworthy characteristic of almost all of these intrusives is their irregular, spotty replacement by siderite; and it is largely to the oxidation of this mineral that they owe their typical brownish colour. In many cases the felsite is so completely replaced by siderite that specimens of it closely resemble ferriferous, crystalline limestone. Small remnants only of orthoclase, acid plagioclase, and muscovite remain as an indication of its original igneous nature. The primary minerals of the sills are quartz, orthoclase, and acidic plagioclase (probably albite-oligoclase), occurring as phenocrysts and as constituents of the groundmass, and muscovite in shred-like grains. One slide contains a large phenocryst of hornblende and another shows micropegmatite occupying the polyhedral spaces between the phenocrysts. The groundmass is usually fine grained and consists of a mixture of the above-mentioned minerals. In places it is glassy with the development of spherulites.

Many of the sills are seamed with a network of quartz veins, some of which carry iron and lead sulphides with gold values. An excellent example of this may be seen on the Dooley-Home Rule ledge on the southeast slope of Barkerville Mountain, where it is intersected by the old Gold Fields hydraulic ditch.

It was found impossible to fix the date of intrusion of these sills and dykes. Neither they nor the quartz veins associated with them were found cutting the Slide Mountain series, whereas pebbles of similar dykes and sill rocks were found in the basal conglomerate of that series. The available evidence indicates that their intrusion was pre-Mississippian.

SLIDE MOUNTAIN SERIES

Unconformably overlying the Cariboo series and the Proserpine sills and dykes is a series of sedimentary rocks consisting of conglomerate, limestone, chert, and indurated shale or argillite, associated with some basic volcanic flows and flow breccias. The series is confined to the northeastern and northern parts of the area. The following description of the series is given by Bowman:

"This formation is remarkable not only for its limestones, but for its cherty rocks, and differs in these respects from any other in the district. Among the chert rocks are occasional beds of volcanic origin, and limestones do not always accompany the cherts. . . . In contrast with the crystalline schists of the gold belt, none of the characteristic crystalline rocks are to be found in it. To this, some of the limestones are an exception. . . . . The most striking characteristic of these beds is the prevalence of greenish cherts, and of jaspery siliceous rocks. Older volcanic sediments occur in all gradations of fragmentation, from breccia to sandstone and from sandstone to shale. The cementing material is usually of a greenish cast, as are the rocks themselves, when compact. . . .

Another feature notable in the rocks of this formation is their regularity of bedding. The rocks are often seen in massive beds, only moderately inclined. . . .

A series of fossils was collected near one of the mining camps on lower Antler Creek. . . . Crinoids are preserved in the limestone, but unfortunately too imperfectly for determination. Their rounded forms afford only presumptive testimony—along with the stratigraphic and lithologic evidence—of an age not newer than Upper Palæozoic."

Bowman's description of the series is essentially correct. It is interesting to note that he named the series "Bear River," probably in allusion to thick beds of limestone occuring along upper Bear River, Swamp River, and Spectacle Lake, just beyond the eastern border of the Barkerville sheet. It has been deemed advisable to rename the series "Slide Mountain" in allusion to the spendid section of the lower part of it on Slide Mountain, and on account of the usage of the term "Bear River" as a formational name in Portland Canal District, B.C.[1]

The Slide Mountain series in all probability is Mississippian in age, and is believed to correspond to the lower part of the Cache Creek series of Dawson.

Guyet Formation

This formation consists of the conglomerate at the base of the Slide Mountain series, and constitutes one of the chief evidences of the unconformable relations of the series with the underlying rocks. The best exposures are along the Bear Lake road, just northeast of the crossing over Eightmile Creek, where a splendid section of almost the entire formation is exposed; on the western slope of Mount Greenberry; and on the top of Mount Guyet. It grades from a somewhat decomposed schistose conglomerate at the base, where no sharply defined boundary with the underlying rocks is observed, to a massive, heavily bedded, bouldery deposit towards the middle part, and a coarse-grained, gritty quartzite near the top. In the uppermost part the pebbles and rock fragments lie in a matrix of grey limestone. A considerable variation in thickness occurs from place to place, but an insufficiency of continuous exposures prohibits a statement of the extent of the variation.

A careful examination of the conglomerate near the mouth of Eightmile Creek revealed pebbles, fragments, and boulders of the following rock types:

Grey quartzite, similar to part of the Richfield formation
White quartzite, similar to part of the Richfield formation
Dark grey limestone
Black slate, similar to the Pleasant Valley formation
Crenulated, red and grey slate, similar to the Pleasant Valley formation
Vein quartz, impregnated with pyrite
Grey and black chert
Coarse-grained, crystalline limestone, similar to the Barkerville formation
Schistose, basic, vesicular lava, similar to part of the Pleasant Valley formation
Granular pyrite
Pebbles and rounded fragments of medium-grained, acidic, intrusive rock (probably monzonite) considerably replaced by carbonates

The smaller rock fragments are well rounded; the larger ones are angular. The lower part of the formation lacks assortment, and the matrix is chloritic and micaceous—not gritty as in a transported gravel. These

[1]McConnell, R. G.: "Portions of Portland Canal and Skeena Mining Division, Skeena District, B.C."; Geol. Surv., Canada, Mem. 32.

characteristics are those of a decomposed residual mantle which suffered little from transportation. Many of the pebbles and fragments are from rock formations which had been previously involved in regional deformation, and intruded by igneous rocks. The fragments of vein quartz and granular pyrite may or may not be from the veins in the Cariboo series. Some of the basal part of the conglomerate was crushed and panned and this operation revealed the presence of placer gold. This points to a period of gold mineralization with subsequent weathering previous to the formation of the base of the Slide Mountain series.

Greenberry Formation

Intermittent exposures of this formation occur immediately northeast of the Guyet conglomerate, and indeed grade into the upper quartzite facies of it. The main rock is limestone, which outcrops prominently on the southern slope of Two Sisters Mountain just beyond the northern limit of the map-area; on the Bear Lake road northeast of the Guyet conglomerate; on the southwestern slope of Mount Murray; on the southwestern slope and on the southeasterly extension of Mount Greenberry; and in an isolated locality about 2 miles due east of Mount Greenberry. The limestone was not located between the Guyet and Antler formations on Mount Howley, or indeed in any locality southeast of Antler Creek. It is a medium-grained, grey limestone, seamed with a good deal of dark-coloured chert. The stratification is only very indistinctly marked. In its two most prominent occurrences on Two Sisters Mountain and Mount Greenberry it is highly charged with crinoid stems, some of which are preserved as chert replacements. It is safe to say that here nearly half the volume of the rock consists of the crinoids. The section of the formation exposed along the Bear Lake road consists of a somewhat thinly bedded, argillaceous phase of the limestone, in which crinoids were not discovered, but which contains a few large tubular structures suggestive of *Orthoceras*.

Waverly Formation

The Waverly formation lies above the Guyet conglomerate, in places almost immediately above it, and in other places separated from it by the Greenberry formation. On account of insufficient exposures and their lack of continuity, it was impossible to locate the horizon of this formation more closely. The most characteristic exposures occur on the tops of Waverly Mountain and Mount Greenberry, but the prevalence of glacial drift in the vicinity prohibited the correlation of the exposures even in localities almost contiguous.

The rocks of the formation consist partly of andesitic and basaltic lava, with prominent pillow structure, and partly of schistose, amygdaloidal, andesitic and basaltic flow breccias. The relationship between these two types could not be ascertained in the field on account of their occurrences in isolated exposures. On the southeastern slope of Mount Murray, close to the 6,000-foot contour, prominent pillow structure is observed in andesite which contains scattered fragments of red quartzite and argillite. On Mount Waverly andesitic flow breccias, largely schistose, contain abundant fragments of red argillite of the Antler formation. In a creek gorge 8,000 feet due east of Mount Greenberry there occurs an area of massive, non-schistose pillow basalt, which is included with the Waverly formation. The pillows vary in diameter up to 5 feet and the inter-pillow spaces are filled with coarse-grained calcite. Vesicles and calcite amygdules are arranged concentrically in the outer parts of the pillows.

Antler Formation

The northeastern corner of the map-area is largely underlain by this formation, which trends southeast from Two Sisters Mountain to Mount Howley. It overlies conformably the Greenberry limestone throughout most of its extent, and outcrops prominently along Antler Creek below its junction with Grouse Creek, on the top of Mount Howley, on the western slope of Slide Mountain, and on the top and western slope of Mount Murray.

The rock types are greyish green, indurated shale (argillite) and grey to white chert, with minor amounts of red, indurated shale and jasper, and some silicified or cherty quartzite. The individual layers of chert and shale are usually from ½-inch to 2 inches thick, with an average of about 1 to 1½ inches. They exhibit remarkable continuity along the strike, and in places are much crenulated. The chert and shale are commonly interbedded.

There is very little evidence of metamorphism in these cherts and so-called argillites. The latter are fissile, parallel to their stratification, but they show no parallel development of mica plates, which is characteristic of slate and argillite. The fissility which they possess is a primary bedding structure and is not due to flow cleavage. Considerable attention was paid to this formation to determine the character of the fissility mentioned above and to discover whether the chert was an original deposit or a replacement. Only in one small exposure was there any evidence seen of a quartzitic or fine conglomeratic fabric partly replaced by chert; in all other cases, the chert appeared to be a primary deposit. Some of the shale beds are not only indurated, but are somewhat cherty, which gives them a marked hardness.

On stratigraphical, lithological, and palæontological grounds there is every reason to believe that the Slide Mountain series is to be correlated with the lower part of the Cache Creek series of other parts of the province.

MOUNT MURRAY INTRUSIVES

The Mount Murray sills are confined to areas underlain by the Antler cherts and indurated shales; a few basic dykes cut the Cariboo series. It was found impossible to map the individual sills, partly on account of the narrowness of many of them, and partly because of their intimate lit-par-lit injection relations to the Antler formation. What is coloured on the geological map as the Antler formation consists predominantly of chert and indurated shale and subordinately of sills. The opposite is the case with the mapping of the Mount Murray intrusives. The line of contact drawn between them on the map separates what is principally chert and shale from what is principally basic sills.

Typical exposures of these sills occur on the southwestern nose of Slide Mountain (Figure 1); on the top of Mount Murray and on the hill lying between Mount Murray and Mount Greenberry; along lower Antler Creek; and on the top of Mount Howley. The basic dykes of this formation are exposed on the saddle due south of Groundhog Lake and in the hydraulic pit of the Point claim on Slough Creek.

The sills and dykes vary in composition between diorite, hornblende diorite, diabase, gabbro, and hornblende gabbro. The dyke south of Groundhog Lake is a hornblende diorite, consisting of idiomorphic to hypidiomorphic grains of common hornblende, hypidiomorphic to allotriomorphic plagioclase (near andesine) much felted with secondary mica, some interstitial quartz and micropegmatite, and small, jointed prisms of apatite. The diorite dyke of the Point hydraulic pit consists of abundant, short, idiomorphic, rectangular grains of andesine-oligoclase with prominent albite twinning, common hornblende, and quartz in minor amount. The sills consist principally of the following mineral groups: hornblende-oligoclase-andesine, uralite-andesine, hornblende-plagioclase (kind undeterminable), diallage-saussurite, augite-labradorite with ophitic pattern, plagioclase-(probably andesine) augite-chlorite with ophitic pattern, and augite-andesine-labradorite with ophitic pattern, irregularly replaced by siderite.

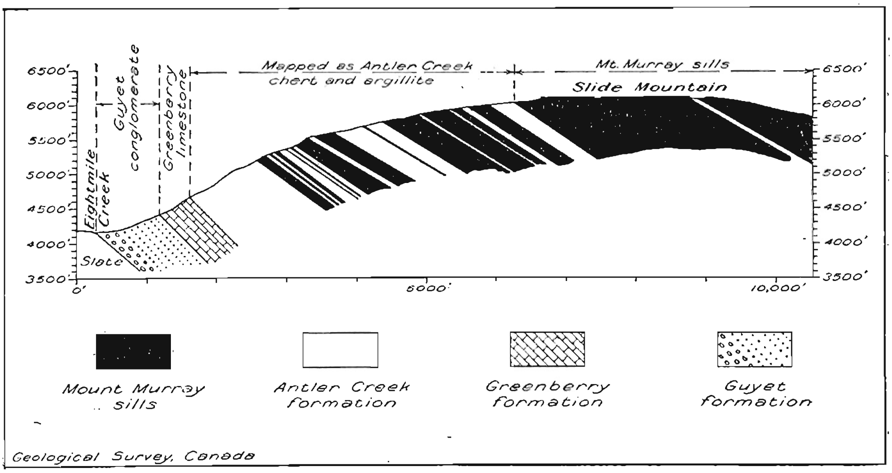

Figure 1. Structure section, Slide Mountain, showing lit-par-lit injection of Mount Murray sills into Antler Creek cherts and argillites.

A single sill of quartz porphyry was found on Mount Murray, in which partly resorbed phenocrysts of quartz occur in a very fine-grained to glassy matrix, showing spherulitic structure.

Strange to relate, some of the narrowest sills (less than one foot) are very coarse grained and show practically no change in size of grain from centre to boundary, whereas many of the thick ones are fine grained and dense. It is quite probable that some of the denser ones are submarine flows, which should be correlated with the Waverly formation.

Small quartz stringers cross the sills in many places and represent the filling of small cross-range fissures. No mineralization was observed in these veinlets.

Very few of the types are perfectly fresh. The feldspars are usually felted with secondary mica, much of the augite is uralitized, and some of the hornblende and augite are chloritized. It is probable that some of the baking or induration of the Antler shales is due to the intrusion of the sills.

Since the Antler cherts and shales are the youngest consolidated rocks in the area, it was impossible to date the intrusion of the sills. The fracturing and faulting they have suffered point to the conclusion that they were intruded before the Slide Mountain series was folded. They are tentatively correlated with the Coast Range (Jurassic) period of intrusion.

TERTIARY

Deposits that are fairly definitely known to be Tertiary in age occur only sparingly in the area and are not exposed except in artificial excavations. Even in the bottoms of narrow, drift-filled valleys such as those of Lowhee and Mosquito Creeks, where the bedrock has been exposed by hydraulicking, glaciated boulders are found in places resting on the bedrock, so that it is evident that nearly all the gravel filling is glacial in origin. There are, however, on the sides and near the bottom of Lowhee Creek, on Williams Creek near the mouth of Mink Gulch, and at other places in the district, localized adherences on bedrock of partly cemented gravels which differ from the glacial gravels in that they contain no glaciated stones and which are, therefore, almost certainly Tertiary.

There are also in places—for example, in Lowhee Valley—numerous angular blocks of the country rock—"slide-rock" of the miners—which rest on the true bedrock in the valley bottom. The slide rock is ancient talus derived from the rock sides of the valley and, as it underlies the glacial drift, is probably Tertiary. It forms, however, only a very small part of the valley filling, and probably occurs only in a few of the narrow valleys which were not eroded to any great extent by the glaciers of the Pleistocene period. In the broad valleys—such as "The Meadows"—which were probably overdeepened by ice-erosion; as is shown on pages 24 and 25, there can, of course, be no Tertiary deposits present. The dumps of many of the old placer drift mines—for example, on Jack of Clubs Creek and above Stanley on Lightning Creek—in many cases show what is described by the placer miners as "flat wash," which formed the bedrock gravels and contained the richest deposits of placer gold. The "wash" consists of angular and partly worn fragments of country rock and quartz veins, and in many cases contains stones of heavy rocks and minerals, such as barytes, galena, etc. It is partly cemented in places. The stones are nearly all local in origin and show no evidences of glacial action, so that it is probable the gravels from which the tailings were derived and which have been largely mined out were Tertiary. No fossils that would throw light on the age of the deposits have been found. There were, probably, large quantities of gravels in the Tertiary valleys of the area, but these were largely reworked during the Glacial period, so that only small amounts of the Tertiary deposits remain.

Residual gravels—that is, gravels consisting dominantly of a resistant rock such as quartz—are only locally present in the area. This is apparently due to rapid stream erosion in late Tertiary time, when, as a result of uplift, the streams had fairly high gradients and much of the eroded material was transported out of the region, fresh supplies of the country rock being constantly added to the stream deposits.

PLEISTOCENE AND RECENT

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

The Recent deposits have been formed mainly by streams eroding the drift deposits and, to some extent, the bedrock. They consist of sands, gravels, silt, and muck or peat deposited in the beds and on the flood-plains and terraces of the present streams. The deposits on the lower terraces of the streams are partly late Glacial and partly Recent, there being no sharp dividing line between the two sets of deposits. The glaciers probably retreated from the region only 10,000 or 15,000 years ago and a small remnant of one of them still remains in the cirque basin on the north side of Mount Agnes. The Recent deposits as a rule are only 10 or 15 feet thick, and in the lower part of Williams Creek and at other places include fairly large amounts of tailings from hydraulic mines. The tailings in Williams Creek are said to average about 25 feet in thickness. In the part above the town of Barkerville and below the canyon there is probably a filling of nearly 40 feet, judging by old photographs of the creek. There are, also, heavy fillings of tailings at the mouths of Lowhee and Grouse Creeks.

Glacial drift is abundant in the area, and in places fills the valley bottoms to a considerable depth, the greatest thickness known being in the valley of Slough Creek opposite the mouth of Nelson Creek, where borings have shown the surface deposits to have a maximum thickness of 287 feet. In many places the drift mantles the sides of the valleys up to more than 1,000 feet above the valley floors and, in some places—as on Proserpine mountain—boulder clay occurs at an altitude of 5,500 feet. At higher altitudes it is mostly thin or is absent, but erratics occur on some of the highest summits—for example on Mount Murray and Mount Agnes—at altitudes of nearly 6,500 feet. The glacial drift in the valleys is nearly all of local origin, though foreign boulders occur. For example, large boulders of conglomerate and numerous pebbles and stones of red argillite, which must have been derived from the mountain ridge on the northeast side of Little Valley and Pleasant Valley Creeks, are fairly abundant in the upper part of Williams Creek and at other places several miles to the southwest of the mountain ridge.

Glacial striæ are well developed at only a few places in the area. They are particularly distinct on both sides of Williams Creek a short distance above the canyon between Barkerville and the old town of Richfield, and on the upper part of Cunningham Creek, where a considerable area of bedrock, glacially striated and grooved, has been exposed by mining. Striæ on the uplands were noted at only one place—Bald Mountain. In the valleys they all trend downstream and were, therefore, probably formed by valley glaciers. No striæ are known to occur in the bottoms of the deep, narrow parts of the valleys, except in the upper part of Cunningham Creek, where, however, the valley bottom is comparatively wide. Moraines formed by valley glaciers occur in Lightning Creek Valley below Stanley; in Slough Creek Valley opposite and below the mouth of Devils Lake Creek; below the mouth of Jack of Clubs Creek; and at other places in the valley bottoms. These moraines, forming as they do part of the surface deposits in the valley bottoms, must have been formed during the closing stage of glaciation. The evidence of valley glaciation is, therefore, much more pronounced than that of an extensive ice-sheet. Nevertheless, the presence of erratics and boulder clay at high altitudes, the foreign derivation of some of the drift in the several valleys, and the occurrence of boulder clay at altitudes too great to be referable to valley glaciers, all go to show that an ice-sheet of considerable thickness did exist. The general direction of movement of this sheet, as indicated by the direction of transport of the erratics, was towards the southwest. The small amount of drift on the uplands, however, shows that the movement was very slight and effected very little transportation of glacial drift, and it seems probable that the upper surface of the ice-sheet coincided very nearly with the surface of the uplands at an elevation of 6,000 to 6,200 feet. The small amount of movement was due to the fact that the ice-sheet throughout central British Columbia, during the time of its maximum development, was practically hemmed in by mountain ranges. It had, therefore, little movement as a whole, but was drained by large glacial tongues extending through the passes.

The average thickness of glacial drift over Barkerville area probably does not exceed 100 feet and was mostly derived from the higher levels. The narrow, V-shaped valleys were eroded only slightly by the ice and there are many places in the area—for example, at the old China hydraulic pit on Wolfe Creek, in the bottom of the Lowhee pit near its head, and at the old bedrock tunnel on the northwest side of Burns Mountain—where the bedrock is deeply weathered to a residual clay and is overlain by unweathered glacial drift. The lack of ice erosion in the deep and narrow valleys explains why gold-bearing preglacial gravels were preserved in places, and were buried beneath glacial drift, which, although abundant, was derived mostly from the upper parts of the valleys and uplands where no preglacial placers now exist.

The glacial drift consists in part of boulder clay and moraine material; in part of stratified, fine sand and silt—the "slum" of the placer miner; and in part of stratified gravels and bouldery deposits. The boulder clay, which is usually referred to by the miners as "clay," in places contains comparatively few boulders and in other places is very stony. The upper weathered part is a yellowish, unstratified clay; the part below water-level is in most places bluish grey. The part above the permanent ground water-level is in many cases hardened or slightly cemented as a result of alternate wetting and drying and is, therefore, difficult to hydraulic. The upper more clayey part of the boulder clay, probably, was formed from materials included in the ice and deposited after its melting; the lower stony clay was formed beneath the ice.

The moraines are composed of materials deposited at the ends of the valley glaciers. Their surface is usually characterized by irregular hillocks and undrained basins; and the materials consist in part of stratified sands and gravels, in part of boulder clay, and in places, for example opposite the mouth of Devils Lake Creek, mostly of angular blocks of the country rock.

Glacial outwash gravels deposited by streams coming from the melting ice in the upper parts of the valleys occur in considerable quantities as valley filling. The glacial gravels in the beds of the streams frequently show imbricated structure, that is, the pebbles dip upstream and overlap downstream and have their long axes in the direction of the current. Glacial gravels also occur in places, as opposite the mouth of Little Valley and along the west side of the upper part of the valley, in the form of irregular hills or kames and as long, winding ridges or eskers. The gravels are in many places coarse and in places are overlain and underlain by boulder clay.

The stratified combination of silt and clay, usually recognized in drilling by its uniform character and almost complete freedom from stones, in many cases forms a considerable part of the valley filling, and in places, as on the east side of Antler Creek opposite the head of Guyet Creek, forms part of the filling of a tributary valley as much as 300 feet above the bottom of the main creek. The silt and clay combination varies somewhat in character in different parts of the area. In places it is a fairly stiff and nearly impervious clay, but for the most part it is composed of fine sand and silt glacial flour—which is readily permeable by water, hence the name "slum." The glacial gravels, especially the coarse gravels and occasionally the fine gravels, referred to by the miners as "chicken-feed," contain considerable quantites of it. The silt shows a fairly regular banding due to an alternation of fine and coarse layers, but no evidence of any definite seasonal banding was noted. It is overlain and underlain in places by boulder clay and in a few places, as at Hamshaw's hydraulic pit on lower Summit Creek, is partly cemented. "Dry slum" or compressed and partly cemented glacial silt is reported to occur on a few of the creeks below water-level. The silt, judging by its even stratification and wide extent, was deposited in a series of lakes formed during Pleistocene time through the blocking of the valley drainage by uneven deposition of drift or—in the case of the northward drainage—by an advance of glaciers from Cariboo Mountains. It is possible, also, that lakes were formed as the result of uneven uplift or depression of parts of the region, but this does not seem very probable, as cutting down of the outlet would probably take place as rapidly as the area was uplifted. The occurrence of stratified silts at heights of several hundred feet above the present valley bottoms shows that they were formerly much more extensive than at present, and the fact that they are overlain at these high levels by boulder clay shows that they were deposited during an early stage of valley glaciation and were much eroded either during a time of temporary retreat of the glaciers or as a result of readvance of the ice. The stratified deposits form a large part of the glacial drift of the area and indicate the great volumes of flood-water which must have existed during parts of Pleistocene time—a remarkable feature, especially considering the fairly high altitude of the area and the small amounts of flood-water at the present time. The area probably stood considerably lower during parts of Pleistocene time, in order to permit of such extensive and rapid melting of the ice as the amounts of stratified deposits indicate, but nothing is definitely known regarding the amounts of uplift and depression of the region.

Interglacial deposits formed during a period of temporary recession of the ice—formerly considered by the present writer as absent in the area—were found at a number of places. The most remarkable occurrence is on the south bank of Lightning Creek about $1\frac{1}{2}$ miles above the junction of Swift River and opposite the old Cold Spring House on Cariboo road, where the following section in descending order is exposed:

	Feet
Soil and river gravels	1
Boulder clay	10
Lignite	1
Stratified silt and sand passing into stony clay at top	10
Boulder clay	5
Stratified glacial silt	1
Oxidized gravels	7
Stony glacial clay and gravels	3

The lignite is composed of carbonized tree trunks and branches and is reported to have consisted, at one time, of a seam 6 to 10 feet thick, but is now mostly eroded away. Although there is a black clay or soil-like layer at the bottom, which can be traced along the bank for nearly 200 feet, it is not certain that the lignite is in place. There are numerous fragments of the lignite in the upper boulder clay immediately above the main deposit of lignite and in the boulder clay exposed along the creek for one-half mile or more downstream. The fragments in the boulder clay show no evidence of shrinkage and, therefore, the wood must have been altered to lignite before it was included in the upper boulder clay. The lignitized wood is too much altered to permit a determination of the kinds of trees from which it was formed, so that there is no fossil evidence of the age of the deposit. It may have been formed in interglacial time, but if so, it seems remarkable that such complete alteration should have taken place. More probably it is of pre-Glacial (late Tertiary) time, and gathered in the valley bottom as masses of driftwood, to be converted later into lignite, which escaped first glaciation to be exhumed and transported by a later advance of the ice. In any case, however, there is fairly definite evidence at this locality of more than one advance and retreat of the ice.

In the central part of Barkerville area drilling records show at several places the presence of pay-streaks that are overlain and underlain by glacial drift. These indicate a period of stream erosion in interglacial time. Apparently the streams did not cut down to bedrock in the lower parts of the valleys, for the pay-streaks are well above the bedrock, but are 40 to 80 feet from the surface. A remarkably rich pay-streak of this character occurs at Eightmile Lake, where pay gravels overlain and underlain by boulder clay have been mined by hydraulicking. The gravels at the surface of the lower boulder clay at Eightmile Lake are somewhat cemented and weathered and there are similar occurrences of cemented gravels and weathered zones beneath unweathered drift on Slough Creek benches and at other places in the area. There is no evidence of a true soil or of vegetation of any kind on these surfaces nor in the interglacial gravels, but the evidence does show pretty clearly that during Pleistocene time there was at least one retreat and readvance of the ice, separated by a fairly long period. The lack of evidence of vegetation during the interglacial period seems to show that climatic conditions were not as favourable as at present. Pleistocene time is generally considered to have extended over at least a million years, so that during this extensive period very great erosion and deposition may have taken place. What seems to have happened, however, in Barkerville area, is that during the great part of the period the area, except possibly on the uplands, was actually protected from erosion by the ice-sheet which was nearly stagnant.

Cemented glacials occur at many places in the area both at the surface and at depths of over 200 feet below the level of the creeks. The cement consists partly of iron oxide and partly of lime or calcium carbonate. The occurrence of cemented gravels in Little Valley, in Willow River Valley at the mouth of Mosquito Creek, and at Slough Creek mine at various depths below the creek level, may be due to the fact that the groundwater has a slow circulation, even at considerable depths, and as a result deposition from it of iron oxide and lime has taken place in post-Glacial time. The relief of the surface would give a head for the water and cause circulation of the ground water. The facts, however, that cementation is known to take place fairly rapidly in gravels near the surface in places where there is a marked oscillation of the groundwater-level or alternate wetting and drying of the material, and that in the deeply drift-filled valleys the cemented gravels occur at considerable depths where the groundwater circulation must be very slow or is stagnant, seem to indicate that cementation of the lower gravels took place during an interglacial period, when the streams flowed at considerably lower levels.

Fossils in the deposits overlying bedrock are not abundant. A fossil tooth was found by the present writer in the tailings from the New Waverly hydraulic pit on Grouse Creek. It had evidently come from the glacial gravels exposed in the pit and has been determined by Mr. Charles Sternberg, of the Geological Survey, as *Elephas primigenius* Blumenbach. A fossil tooth, probably similar in character, was found about 1900 by James Craig, Quesnel, in the bedrock gravels of the deeply buried channel at the old Bonanza mine on lower Lightning Creek. These fossils indicate that the deposits in which they occurred are Pleistocene in age.

GEOLOGICAL STRUCTURE

The geological cross-section accompanying Bowman's report on the "Geology of the Mining District of Cariboo"[1] presents the only available

[1]Geol. Surv., Canada, Ann. Rept., vol. III (pt. I), pt. C, facing p. 26 (1889).

information on the general structure of this part of the Interior Plateau. This section extends from the crest of Cariboo Range for a distance of 55 miles in a southwesterly direction across the Cordilleran trend through Quesnel Forks to Guy Mountain, west of Beaver River. Bowman shows the main part of this district to be underlain by the Cariboo series in the attitude of open folds trending northwest. On the northeastern end of the section they outcrop as the main part of the Cariboo Range and are followed to the southwest by the overlying Bear River beds (Slide Mountain series), which continue approximately to the line of the unconformity shown on the Barkerville geological map. West of this line, Bowman shows the Cariboo series again coming to the surface in a broad anticline whose crest passes through Mount Agnes, and continuing to the vicinity of Cariboo Mountain and Keithley Creek, beyond which they dip under the Mesozoic, Quesnel Lake beds.

Two important features that bear on the structure of Barkerville area are brought out by this section: (1) the open character of the large folds; and (2) the fact that the Bear River beds (Slide Mountain series) occur in a broad syncline whose southwesterly limb comes to the surface at the line of the unconformity mentioned above, and whose northeasterly limb outcrops along the western face of the Cariboo Range. The only major intrusive rock body shown on Bowman's geological map, which covers nearly 3,000 square miles, occurs on Mount Stevenson, on Quesnel Lake. There is the important fact, therefore, of the general absence of major intrusives cutting the gold-bearing Cariboo series.

The major structural feature of Barkerville area is a broad, open anticlinorium, whose axis trends north 55 degrees west from the top of Mount Burdett, through Mounts Agnes, Pinkerton, and Amador, to Mount Nelson (*See* Map 2046). On the northeastern side of the axis the beds have a general northeasterly dip, varying from a few degrees near the crest to 70 degrees at a distance of 7 miles from it; whereas on the southwesterly side the beds have a general southwesterly dip varying from a few degrees to 35 degrees at a distance of 5 miles. The anticlinorium pitches a few degrees to the southeast.

Both the Cariboo and Slide Mountain series are involved in this anticlinal structure. Within the limits of the map-area the Slide Mountain series is exposed only on the northeastern limb. Owing to a covering of glacial drift and a thick mantle of vegetation it was impossible to obtain sufficient exposures in the southwest corner of the area to interpret the geology, but at the few available exposures no indication was seen of rocks of the Slide Mountain series. They may have been removed by erosion, as the erosion plane dips about 75 feet a mile in that direction.

The main structure of the anticlinorium consists of a broad, open fold, controlled by the Barkerville limestone formation, the heavily bedded, non-schistose, dark-coloured quartzite members of the Richfield formation outcropping along the crest, and the Slide Mountain series and Mount Murray sills acting as competent horizons. These horizons are characterized by simple, large-scale, open structures and a general regularity of strike and dip. Between them occur, as the incompetent parts of the structure, the slates and associated rocks of the Pleasant Valley formation, and the thinly bedded, argillaceous, and schistose members of the Richfield formation. These incompetent horizons are characterized by pronounced drag-folding with very wide variations in dip.

Even the competent horizons, particularly the Barkerville formation, afford evidence that although they control the intimately dragged structures of the incompetent horizons their own beds are somewhat drag-folded, indicating that, with respect to still larger geological units involved in the folding, they themselves were somewhat incompetent. During the folding this rock must have been incompetent relatively to some larger and more resistant unit, and it yielded first by drag-folding and recrystallization. This deformation had the effect of thickening the limestone and rendering it more competent and more capable of transmitting the thrust over broad areas. To this thrust the more thinly bedded quartzites and argillaceous rocks yielded by close folding and recrystallization into schists and plates. Zones of intense crumpling and shearing developed in these softer rocks and became partly mineralized with quartz (*See* Map 2046).

With regard to the relationship of the thickness of the formations to their structures, Bowman makes the following statement:

"As it would be unsafe, where the rocks are so frequently on edge, to draw conclusions regarding their thickness from any general section, however accurate, attention may be directed to the following distances on the Cariboo map, where a constant dip in the same direction was observed. On Williams Creek such uniformity occurs for 5 miles; on Antler Creek it occurs for 4½ miles. . . In Devlin's diggings at the foot of the Williams Creek section, and again at Mink Gulch above Richfield, the attitude is vertical. Above these points are seen the usual gentler northerly dips. There is probably a repetition of beds on Williams Creek, such as is indicated on that part of the general section corresponding to it. . . In that part of the section corresponding to the crest of Goose Creek Mountains, it will be better in accordance with the facts to conclude that some beds have been inverted, than it would to assume a thickness of 30,000 feet. The total thickness of the schists (Cariboo series) is probably as has been indicated on the section, from 5,000 to 8,000 feet."

Bowman's conclusions with regard to the thickness of the Cariboo series agree in general with those based on the present investigation: but the two methods of arriving at the same result were different. Bowman apparently failed to recognize the difference between cleavage and bedding planes in the schists and slates, and assumed, for instance, that a thick series of parallel dips meant a corresponding thickness of strata. The figures he obtained for stratigraphical thickness were so great that he deemed it advisable to divide them by three to six to arrive at a more reasonable result. In the detailed field work on the structure sections carried out in connexion with the present report, abundant testimony was obtained regarding the lack of coincidence of cleavage and bedding planes in the schistose and slaty rocks. Many localities were seen in which the cleavage planes of these rocks maintained a northeasterly dip on the northeastern limb of the anticlinorium, whereas the bedding planes were observed to be intimately crenulated, but to have in general a nearly horizontal attitude. In other words, the flow cleavage planes were seen to be parallel to the axial planes of the drag-folds. Sufficient evidence of this relationship and structure was obtained to prove that a very decided repetition of beds in the Cariboo series exists—not such, however, as might be produced by strike faulting (although that also occurs), but a repetition of an intimate character in which each bed is repeated several times as a result of closely packed drag-folds. Unfortunately the field evidence provided no factor by which to reduce the apparent thickness in order to arrive at a true figure, but it can safely be said that Bowman's factor of three to six as a suitable divisor is not far from correct. The thickness of the exposed Richfield formation, as estimated from the geological structure sections, is not over 8,000 feet; that of the Barkerville formation not over 2,500 feet; and that of the Pleasant Valley formation about 5,000 feet.

The intimate folding characteristic of the softer beds of the Cariboo series is not developed even in the incompetent interbeds of indurated shale of the Slide Mountain series. The deformation of this series was consequently much less severe than that of the Cariboo series, although it is of the same general character. Evidently there were two periods of folding—the period of more intense folding being pre-Mississippian; that of less intense folding being subsequent to the intrusion of the Mount Murray sills. The beds of the Slide Mountain series do not seem to have been repeated by close folding, so that the thickness exposed in Barkerville area may be read directly from the geological structure sections.

The Slide Mountain series with its upper formation of massive, thickly bedded limestone (as exposed along Spectacle Lake, Bear River, and Swamp River, to the east of Barkerville map-area) appears to lie in a synclinal attitude between the Mount Agnes anticlinorium on the southwest and the Cariboo Range anticlinorium on the northeast. Lack of knowledge concerning the nature of the contact of this upper limestone with the rocks of Cariboo Range prevents a more definite statement of these structural relations.

Three types of faults occur in the area:

Reverse faults of compression
Strike faults of tension
Normal cross-range faults of tension

Reverse Faults of Compression. As an incident of the folding of the Cariboo series, thrust faults of small magnitude developed along the crests of some of the minor folds. The most striking evidence of this faulting may be observed at the crest of the main anticline where it crosses Mount Agnes (*See* Geological structure section). Other faults of the same type occur, but were either too difficult to locate or too small to map.

Strike Faults of Tension. Only one fault of this character was found in the area. It extends from Ninemile Lake to a point on the southwestern slope of Mount Guyet, but in no place was its outcrop observed. Its location on the map is based on the relations of the adjacent formations to one another. Its strike corresponds in general with that of the formation, but its dip is inferred to be towards the southwest or opposite to the dip of the formations. The character of this fault is brought out particularly well on the geological map (No. 2046) by the areal relationship of the two belts of the Barkerville formation, which coalesce on the southwestern slope of Mount Guyet. The faulting is believed to be normal and of the hinge or rotary type; and the country southwest of the fault is believed to have dropped relatively to that on the northeast. Owing to the overburden, no details of the nature of this fault could be obtained. The actual displacement along the plane of the fault, where the geological section line A-B crosses it, is about 6,000 feet.

This hinge faulting was an aftermath or consequence of the formation of the anticlinorium. It was completed before the initiation of the later folding which involved the Slide Mountain series, since the sequel of this later folding was the series of cross-range faults that crosses and offsets the hinge fault.

Normal Cross-Range Faults of Tension. A very large number of normal faults with trends varying from north 15 degrees to 40 degrees east cross all the formations of the map-area. Their dips vary from northwest to southeast, but are invariably steep. Eleven of the most prominent of these faults are shown on the geological map. As stated above, they appear to be a consequence of the second period of folding, and they represent an attempt to re-establish the condition of stability which had been upset by the folding. The rocks of the entire area are sliced by joints and faults with a northeasterly trend, so that after the elevation due to folding was complete, the blocks of rock between the main faults settled down against one another and produced the effect of block-faulting.

Two of the most outstanding of these faults are: the one that runs down Grouse Creek and across Antler Creek; and the one that passes through Cornish Lake, Cornish Creek, and Willow River. The last one causes an apparent horizontal offset of about 4 miles. Neither of these faults could be actually traced in the field, but their presence was determined and located by the outlines of the faulted rocks.

Smaller faults belonging to this group can be easily detected on Slide Mountain, Mount Murray, and Mount Greenberry, where rock exposures are good and where variety of strata lends itself to the actual observation of offsets. Within the area of the Cariboo series it was very difficult to determine the offsets, but a cross-jointing, parallel to, and correlated with, these cross-range faults, occurs very prominently in the quartzites and slates.

Unconformity at the Base of the Slide Mountain Series. With regard to the relationship of the Cariboo and Slide Mountain series Bowman makes the following statement:

"These gold schists (Cariboo series) are much more highly altered than any of the rocks in the Bear River series. Their junction, as observed on Antler Creek, below Pleasant Valley Creek, exhibits, however, a similarity of strike and dip suggestive of conformability. But the greater degree of metamorphism is apparent at a glance, and is alone good evidence of their greater age . . . . The presumption is that they constitute some part of the lower Palæozoic—perhaps even pre-Palæozoic—system."

Reference to Bowman's geological map and to Map 2046 will show that the line of junction of the two series as mapped by Bowman lies within or near the western edge of the Barkerville formation of the Cariboo series. Bowman included the massive outcrops of the Barkerville limestone in this vicinity in his Bear River series, and thus failed to recognize the actual position and character of the break between the two series. As a matter of fact, this stratigraphical break is not evident along Antler Creek owing to a covering of drift and vegetation; but it may be readily examined along the southwestern slope of the ridge extending from Antler Creek to Summit Creek.

Bowman's general conclusion regarding a probable unconformity is substantiated, since such a stratigraphical break has been found to be continuous for at least 12 miles beyond the northeastern corner of Barkerville map-area.

The evidence of the unconformity may be summarized as follows:

(1) There is some discordance of strike and dip between the two series. Discordance of strike is shown on the geological map due west of Mount Murray, where the Guyet formation lies across the contact of the Barkerville and Pleasant Valley formations. Discordance of dip is shown on the geological structure sections.

(2) The Guyet conglomerate rests on an erosion surface of the Cariboo series, and contains pebbles and boulders of the underlying formations of that series. The basal part of this conglomerate is clayey and somewhat schistose, and appears to grade into the underlying slate and schist. This part, therefore, is the result of the metamorphism of an old residual mantle of clayey decomposition products.

(3) Pebbles of folded, crenulated, slaty, and schistose rocks in the conglomerate are proof of the metamorphism of the Cariboo series before the deposition of the base of the Slide Mountain series. Pebbles of medium-grained intrusive rocks indicate that erosion removed a considerable thickness of the underlying rocks before the formation of the conglomerate.

(4) There is a decided difference in the degree of metamorphism to which the rocks of the two series have been subjected. The Cariboo series is characterized by quartzite, slate, and schist, whereas the Slide Mountain series is made up of indurated shale, chert, and massive, fossiliferous limestone.

(5) Felsite and quartz porphyry dykes, much replaced by siderite, occur only in the Cariboo series.

(6) There is an absence in the Slide Mountain series of large quartz veins which are such characteristic features of the Cariboo series.

(7) The Mount Murray sills occur abundantly in the upper series and very sparingly in the lower or Cariboo series.

(8) Placer gold was found in the Guyet conglomerate, but the boundaries of the rich placer fields of the area do not include any of the country underlain by the Slide Mountain series.

GEOLOGICAL HISTORY

Richfield Epoch

The earliest events consisted of the deposition of coarse quartz sand and fine quartz pebbles with a few layers of sandy and carbonaceous clay. The subangular character of the grains of the rocks of this epoch, the prevalence of iron oxide as a cementing material, the rapid variation from fine to coarse grain, the occurrence of structures caused by contemporaneous erosion, and the great thickness of the series point to conditions of continental deposition in localities of considerable relief. Whether the high country from which the sediments were derived lay to the east or the west could not be determined from a study of the local geology.

Barkerville Epoch

Deposition of the arenaceous sediments was followed by that of limestones, containing numerous sandy and clayey beds, indicative of lower relief and clearer water.

Pleasant Valley Epoch

Deposition of calcareous and carbonaceous clays and volcanic ashes characterized this epoch. Near or after its close, basic lava was extruded subaerially, as shown by its brecciation and total lack of pillow structure.

Epoch of Deformation, Intrusion, and Erosion

After deposition of all the preceding formations, the country was mountain-built, the formations were folded along northwesterly trending axes, and recrystallized into quartzites, schists, and slates. Great shear zones and hinge faults were developed, and the Prosperine sills and dykes of quartz porphyry and felsite were intruded. The intrusion of the sills and dykes was intermittent and continued throughout the time of deformation, since some of them are schistose, and some of them are distinctly granitoid. It was during this time, and as an accompaniment of the sill and dyke intrusion, that the shear zones of the Cariboo series were extensively replaced by great lenses and veins of quartz ("A" veins). Both the minor intrusives and vein deposits were probably offshoots from, or genetically related to, major intrusions which erosion did not succeed in unroofing before the subsequent submergence of the country beneath the Mississippian sea.

The first series of cross-range faults was formed by the settling down of the country after its elevation into the anticlinorium. These faults were then healed with quartz, and mineralized with galena, pyrite, sphalerite, and highly auriferous arsenopyrite ("B" veins).

Slide Mountain Epoch

Gradual submergence of the country beneath the Carboniferous sea which covered a large part of British Columbia caused the partial assortment and burial of the surface debris of the previous epoch of denudation, and the formation of the Guyet conglomerate. The presence of free gold in the conglomerate points to the existence of auriferous lodes reaching the old surface of the Cariboo series; the liberation of the gold during the intervening erosion epoch; its concentration in the surface debris; and its possible later transportation and deposition as beach placers in the Guyet conglomerate.

During the Slide Mountain epoch, there ensued the deposition of beds of grit (top of the Guyet formation), the formation of the crinoidal Greenberry limestone, and the deposition of alternating thin beds of chert and clay. The association of basic lava flows of the Waverly formation with the chert and indurated shale points to contemporaneous vulcanism. Succeeding these events, there was the deposition of a considerable thickness of massive limestone (as exposed on Spectacle Lake, Swamp River, and Bear River) which is probably the equivalent of Dawson's Marble Canyon limestone of Pennsylvanian age.

Mount Murray Epoch

The next event was the intrusion of the Mount Murray basic sills and dykes into the cherts and shales of the Antler formation. There is no field evidence regarding the date of these intrusions. Since the sills are sliced by the cross-range faults which were the aftermath of folding, it is probable that their intrusion took place while the cherts and shales were still horizontal. The age of the sills has been tentatively given as Jurassic, thus correlating them with the period of the intrusion of the Coast Range batholith.

Epoch of Deformation and Erosion

Following the intrusion of the basic sills, the country was again compressed by orogenic forces and formed into a broad anticline whose axis extended along the same course as that of the previously formed anticlinal structure. In this case, however, the folding was not intense, and the Slide Mountain series and associated Mount Murray sills were not metamorphosed. Following this folding or differential elevation of the country, a tendency for the uplifted formations to settle down again exerted itself, and found expression in the block-faulting of the formations along northeasterly trending fissures. Many of these adjustments took place along the planes of the "B" veins, which yielded by the fracturing of their quartz, pyrite, arsenopyrite, and sphalerite, and the flowage of their galena.

A long period of erosion succeeded this deformation and resulted in the peneplanation of the country, possibly in late Cretaceous time. Upwards of 15,000 feet of strata were removed from the axial part of the anticline, thus exposing the hard, massive quartzites near the base of the Richfield formation.

Tertiary and Quaternary Records

The Tertiary record is very incomplete, and it is difficult to determine just what features of the present topography should be referred to this long period whose record in the area appears to be very largely that of erosion. In the lower part of Quesnel River basin and along Fraser River west and northwest of Barkerville area, there are extensive and thick Tertiary sediments overlain in places by lava flows. The upper surface of these sediments near Quesnel stands at about 2,500 feet. Barkerville area was the source of part of the sediments, for the drainage of the area is towards the Tertiary basins, and as the lowest parts of the present bedrock valleys are about 3,700 feet, it is possible the valleys were eroded to within a few hundred feet of their present depth in Tertiary time. This amount of erosion, however, is small as compared with that of many other parts of the world where thousands of feet of strata are known to have been deposited and again eroded during Tertiary time. It may be that the Tertiary lava flows in this general region were formerly much more extensive than the present remnants seem to indicate, and that much of Tertiary time was consumed in erosion of the lavas without greatly eroding the underlying rocks. The depth of erosion of the valleys and the occurrence of deeply weathered bedrock beneath unweathered glacial drift of the Pleistocene period indicate that much of, if not nearly all, the placer gold was freed from the bedrock and was concentrated in the old stream channels of the Tertiary period.

During parts of Pleistocene time, valley glaciers were extensive in the region and accomplished considerable erosion of the bedrock, especially by cirque action near the heads of the streams and by overdeepening in places the broad valleys of the main streams, whereas the narrow, V-shaped valleys became filled with glacial drift and were only slightly eroded. At other times one or more ice-sheets covered all the area except possibly a few of the highest points. The ice-sheets appear to have had the effect in the main of protecting the region from erosion, for they were nearly stagnant and transported little drift from one part of the region to another. There is evidence of one interglacial period during which the glaciers almost entirely disappeared and considerable erosion of the drift deposits took place. Gold placers were formed in a few places, mainly by concentration from the glacial drift, for the bedrock was not eroded to any great extent. The interglacial period was followed by development of valley glaciers, and possibly also an ice-sheet, although there is no very definite evidence as to how extensive the later glaciers were. Valley glaciers extended far down the valleys in late Pleistocene time and finally dwindled to the very small remnants existing in the district. The presence of large quantities of stratified glacial sands and gravels shows that powerful streams, formed from the melting snow and ice, existed at various times, and the presence of evenly stratified glacial silt and clay at high levels shows that glacially dammed lakes also existed. The preglacial or Tertiary gravels in the stream valleys were mostly reworked and incorporated in the glacial drift, so that Pleistocene placers were formed, though the gold in them was mostly derived from the older placers. During the closing stage of glaciation the drift deposits were terraced in many places by ice-border drainage along the sides of the valleys. This action also caused some slight concentration of placer gold.

Since the disappearance of the glaciers (except for some small remnants) a few thousand years ago, the streams have eroded the drift deposits, and, to a small extent, the bedrock. In the valley bottoms the erosion has resulted in steep-sided rock canyons, some of which are more than 100 feet deep, but in the uplands the erosion was only slight. The broad valley bottoms have been aggraded in places and degraded and terraced in other places to form nearly level alluvial flats; a soil has been developed and extensive deposits of peat have been formed. Some concentration of placer gold has been effected, especially in places where the streams have cut down through the drift to, or nearly to, bedrock. Weathering of the bedrock and gold-bearing veins, though only slight, has freed some of the gold, which is transported by soil creep for short distances down the hill-sides and affords to the prospector a means of locating gold-bearing veins that are in many places covered only with small thicknesses of soil and glacial drift. Earth and loose rock slides have occurred at many places in the area, especially in the narrow, steep-sided valleys, but are not prominent features, for few of the valley slopes are very steep and the mantle of thick vegetation effectively checks earth slides.

ORIGIN OF THE PHYSICAL FEATURES

One of the most striking features of the area is the nearly flat character of the uplands at elevations of 5,500 to 6,300 feet, the highest parts being in the south-central area and the lowest in the northwestern. The structure sections across the area (*See* Map 2046) show that a great thickness of rock has been eroded from even the highest parts. The rounded or gently rolling and flat-topped summits at nearly accordant levels with a general northwest or west slope towards Fraser Valley, show that the area at one time was reduced by erosion to a gently rolling plain. Across this plain streams flowed at no great depth below the present upland surface. This old, plain-like surface has been dissected in places to depths of over 2,000 feet, and must have been uplifted to permit of such deep dissection. In the eastern part of the area, in the bottom of the main valley of Antler Creek, there are narrow rock canyons 100 to 200 feet deep, which indicate that a later, small amount of uplift, probably late Pleistocene, also occurred. Between Barkerville area and Fraser River at Quesnel, the general level of the surface is about 3,000 feet, but gradually decreases towards the valley of the Fraser, which, at Quesnel, is several miles wide, and nearly 1,000 feet below the plateau level, a part of the Interior Plateau as defined by G. M. Dawson. A few miles southeast of Quesnel there is, however, a mountain ridge, which appears to be nearly as high as the lower summits in Barkerville area and, therefore, rises considerably above the Interior Plateau level in the vicinity. Its top may represent an extension mostly eroded away of the upland, plain-like surface in Barkerville area. If this is so, the upland surface in Barkerville area is much older than the Interior Plateau and is about 3,000 feet higher.

In view of the immense time that has elapsed, it would be unreasonable to contend that the nearly flat upland surfaces in Barkerville area are actual remnants of an old peneplain; it is believed, rather, that they represent a degraded form of the old surface. The remarkably flat surfaces, for example, on Bald Mountain, are most likely due to glaciation. The scantiness of drift on the uplands indicates that the surface of the ice-sheet stood for a long period at about the level of the upland surface, and that this surface was gradually degraded by frost and wind action and by slow creep of the eroded material to the level of the ice-sheet.

The stream valleys of the region have a pattern that indicates a control by the structural features of the bedrock, but in places the pattern is very irregular because of the results of stream capture and of reversal in places of the direction of drainage. Several of the valleys trend in the general direction of the axes of folding of the rocks; others are nearly at right angles along the direction of cross-fracture of the rocks. The main valleys were formed for the most part by stream erosion in pre-Glacial time, but there were many changes in the character of the valleys and in the direction of drainage as the result of glaciation and of stream capture.

VEIN DEPOSITS

Almost from the commencement of placer mining in 1860, the existence of numerous quartz veins was noticed, but no particular attention was paid to them until the yield of alluvial gold began to be seriously diminished in 1875 and 1876. About this time the prospectors turned their attention to the exploration and development of many of the veins. The Provincial Government established reduction works at Barkerville for the treatment of the quartz ores; several small stamp mills were set up in the district; several shafts and tunnels were driven, and many tons of ore were tested. Considerable free gold was obtained from the oxidized parts of the veins, but very little from the sulphides. None of the deposits was scientifically explored or exhaustively tested, but until 1907 the veins continued to receive some attention.

Failure during the past forty-five years or so to discover a quartz mine in this district does not necessarily warrant the inference that the values are too low for successful mining. In addition to the general low grade of the deposits there are many other reasons for the failures, such as expensive transportation, the difficulty of bringing in machinery, the absence of modern mining and milling equipment, the lack of prospectors with experience in lode deposits, and the manifest failure on the part of the miners to appreciate the character and potentialities of the veins.

There was considerable justification for the unbounded confidence of the local mining community of the early days in the future successful development of the veins. The area has an abundance of quartz outcrops, indicating widespread mineralization; upwards of $30,000,000 was extracted from the gravels of restricted sections of Williams, Lightning, and Antler Creeks and their tributaries; the gold was generally coarse, much of it was angular and associated with quartz, indicating a local origin; the outcrops of many of the veins contained small bonanzas of free gold; and the belt of quartz veins crossed the country near the upper auriferous limits of the pay-gravels. These facts are a satisfactory vindication of the confidence of the early miners and the government officials; and today, when that confidence is almost destroyed, owing to the record of failures, the same facts point to possibilities that are worthy of serious consideration in the light of recent progress in the methods of mining and treatment of low-grade lode deposits in general.

At the present time, there are available for examination very few openings on the veins. Most of the underground development conducted from 1876 to 1905 is now inaccessible, and in the work of the past four or five years exploration was almost entirely confined to the surface.

CHRONOLOGICAL RÉSUMÉ OF LODE MINING

Unless otherwise stated material for this résumé has been taken from the reports of the Gold Commissioner, contained in the Annual Reports of the Minister of Mines of British Columbia from 1876 to the present.

1876. A 4-stamp mill was erected at Richfield to treat ores mined from the Bonanza ledge at the head of Lowhee Creek. Assays of $80 in gold and the same in silver a ton of ore were reported.

Quartz was being mined from a vein in Black Jack Canyon, Williams Creek.

From a ledge in Sixmile Creek, a tributary of Swift River, 50 pounds of quartz, sent to San Francisco, returned $125 in gold and silver a ton.

1877. "Thirty-six quartz mining claims have been made since Mr. Harper's arrival, upon some of which work is being prosecuted with vigour. I may mention particularly two companies, the Cariboo Quartz Mining Company and the Enterprise Company. The former have two locations, the Steadman, a real estate claim, and a pre-emption on the Bonanza lode. The company is now running a tunnel on the Steadman vein, whence the rock, after being sorted, is hauled on a tramway to the mill and crushed. It is from this lode that the first test is being made, probably 40 or 50 tons. When the result is ascertained, a test will then be made from the Bonanza location, a tunnel being run through bedrock to crosscut this ledge. It is expected that by the time the test is made from the Steadman, this tunnel will have opened up the vein at about 50 feet deep........

The Enterprise Company, situated on the west side of Lowhee creek, on what is supposed to be an extension of the Bonanza ledge, is about to let a contract for about 200 feet of bedrock tunnel to crosscut the ledge at about 200 feet deep. This claim is very favourably located for prospecting; the face of the mountain being precipitous, will admit of comparatively short tunnels cutting the ledge at very great depth"........

(NOTE. For the results of the development mentioned above, with assays, *See* under descriptions of the respective properties.)

The St. Lawrence Company ran a cut across the eastern extension of the Big Bonanza ledge.

The Pinkerton ledge, believed to be a western extension of the Bonanza, has been opened up to a depth of 150 feet in the Victoria Company's ground.

The Foster mine, Chisholm Creek, has a shaft 18 feet deep with promising indications.

1878. "There has been a complete suspension of work on all claims located on the Bonanza lode. The B.C. Milling and Mining Company, after expending nearly $100,000 in the purchasing and importation of a 20-stamp mill, the grading and tunnelling of their mine (Bonanza lode), suddenly suspended all operations.

Among the companies at present working, the Enterprise is perhaps taking the lead in the development of their mines. Having purchased Mr. Samuel Walker's location on Island Mountain, near Mosquito Creek, they employed some six or seven men during the last three months in taking out ore, and at present they have 300 or 400 tons on their dump ready for hauling to the mill. They have also procured the use of ten stamps with their appliances from the B.C. Milling and Mining Company and have placed them in the old Lane and Kurtz shaft house on Williams Creek meadows where they have ample facilities for working the mill either by steam or waterpower.

Mr. J. C. Beedy of Lightning Creek is also erecting a small quartz mill, having a capacity equal to five ordinary stamps. . . . The flattering result obtained from 1½ tons of ore brought from his location on Burns Mountain (Perkin's ledge) and crushed at Richfield, had induced Mr. Beedy to erect this mill. At present, there are over 200 tons of rock ready for hauling to the mill, and some twelve men are employed in connexion with this enterprise.

The Forrest Company whose mine is situated on the mountain (Proserpine) about one mile east of Richfield, have been working until quite recently. They have now suspended all operations pending the result of negotiations with Mr. Edwin Russell of San Francisco, with a view to placing a mill of the capacity of 10 stamps on the mine.

The Proserpine Company are sinking on their claim, which is situated near the Forrest mine. This location is most favourably situated, being, it is supposed, where the Wilkinson and Montgomery lodes join."

1883. "The Burns Mountain Quartz Mining Company are prosecuting work on their tunnel with vigour. The tunnel when completed will be 600 or 700 feet in length"....

Burns Mountain Quartz Mining Company pushed their tunnel ahead to a point at which they expected to crosscut the ledge. Failing to find this, work was suddenly stopped.

A 12-foot shaft was sunk on a ledge 30 miles south of Barkerville by Dominion Quartz Ledge Company.

1886. "Mr. P. C. Dunlevy of Soda Creek, proprietor of the Island Mountain mine, was the first apparently to grasp the new order of things, and believing that a quartz mine in Cariboo was no longer to be a place in which to sink capital without a probable chance for a return has commenced the vigorous prosecution of work on his mine continuing the tunnel into the mountain on the ledge which improves as depth under the mountain is reached.

The British Columbia Milling and Mining Company having re-located the old Cariboo location on the Bonanza Lode have called for tenders for the sinking of 50 feet in the old shaft.

The Burns Mountain Quartz Mining Company have during a great part of the season had men under charge of Mr. Jaques of Victoria at work running drives in search of the main lode, but of the result of their labour I am not informed further than that they have now driven in over 800 feet, and consider the indications good.

The Dominion Company have re-located the old Steadman Lode of Richfield, and are sinking on the ledge which shows a remarkably firm body of ore and a well-defined ledge, within good casings."

1887. Upwards of 100 miners were engaged during the season in work connected with the development of the quartz veins.

British Columbia Milling and Mining Company employed a large force in sinking their shaft to 100-foot level, then drifting 100 feet on the vein. Here the vein is 26 feet wide and "shows some very rich rock, although much the greater portion is considered worthless to work under any process known at present."

Island Mountain Company employed forty to sixty men in removing their 10-stamp mill from Kurtz and Lane works to Jack of Clubs Lake, in putting up buildings, erecting machinery, and taking out ore. Some half dozen men are working in the mine taking out ore. Some excellent ore was reported as being mined.

About one hundred quartz claims have been recorded this year. Many are new locations.

On Lowhee Creek, Messrs. Pinkerton and the Flynn Bros. are putting up an arastra to thoroughly test their ore.

The Black Jack claim "has developed a very rich body of ore, and is now taking out rock from which (after being pounded in a mortar) a good prospect of free gold is readily obtained."

1888. Reduction works being erected at Barkerville by the Provincial Government.

1890." Destruction by fire of the Government Reduction Works last winter; rebuilding of the same upon a somewhat increased capacity, which undertaking has been accomplished and the works are now in operation again.

The Island Mountain Company completed their 10-stamp mill, to which is attached four concentrators and an improved rock crusher, and the machinery was put into operation about August 20, and was found to work satisfactorily. Rock crushing commenced on August 25, and by September 25 several hundreds of tons were put through. Some difficulty was experienced in getting the silver plates to catch the gold, owing to the presence of some foreign substance coating the plates, but after a time this was partly remedied. Some fifteen or twenty tons of sulphurets were saved and brought to the Government Works for treatment."

1891. The Black Jack Quartz Mining Company was the only company to do any work this season. They sank their shaft to 125 feet, crosscut 75 feet through hard rock, and finally struck the ledge. The vein here is 5 feet wide. Messrs. Martin McArthur and Company located and worked a mine on Island Mountain this fall, which is likely to prove valuable. The ledge is about 12 feet in width, assays $25 per ton, and is nearly all free gold. The vein has been traced several hundred feet.

Mr. Perkins, on Burns Mountain, continues to work his man-power arastra and manages to make his living from it while prospecting the mine.

1892. The Black Jack Company baled out their shaft to the 64-foot level and commenced taking out and milling ore with their one-stamp mill.

1895. Cariboo Reef Development, Limited, of London, England, commenced a tunnel on the Princess Maria claim (?) to tap the lode.

1902. "Comparatively speaking, little has been done to further develop the numerous quartz veins of the district, if I except the work at present being done by Messrs. Baker and Atkin, of whose efforts in this direction Mr. Atkin speaks as follows:

'Mr. C. J. S. Baker and myself devoted all the working season to prospecting quartz in the neighbourhood of Barkerville. We have bonded the Pinkerton claim and the B.C. Milling and Mining Company's location, both on Lowhee Creek, and two of E. Perkin's claims on Burns Mountain. A considerable amount of work was done in prospecting these properties by sinking shafts, driving tunnels, and pumping out old workings. A large amount of assaying has been done, and is still going on, both on samples from these properties and a number of others. The Government Reduction Works, with its one-stamp mill and cyanide plant, was leased, and samples of ore from 1,500 pounds to 15 tons, were crushed and treated. As neither the series of assays nor treatment of ore is complete at the time of writing, it is impossible to give the results definitely. Though a number of the reefs examined have turned out to be too low grade to be worked at a profit under present conditions, it is believed, nevertheless, that several will be well worth working with modern methods, and it is intended to renew investigations as early as possible next year.'"

The Annual Report of the Minister of Mines of British Columbia for this year contains a complete survey of the quartz properties by W. Fleet Robertson, Provincial Mineralogist.

1903. "Messrs. Baker and Atkin, backed, it is understood, by English capital, have devoted the season to an examination of the numerous quartz ledges in the vicinity of Barkerville. Mr. Atkin furnished me with the following: 'The working season of 1903 was chiefly spent in further investigation of the quartz properties on Burns and Island Mountains. A great deal of work was done on Island Mountain, clearing out old tunnels with a view to finding out why work was not more vigorously prosecuted. It is to be regretted that, after having such encouraging prospects as the oxidized surface ores afforded, no effort was made to sink on these reefs. Although tunnels were driven in every direction, some of them 400 feet long, not one proves the reef below 50 feet. . . . . Several of the old miners reported that tellurides had been found in the reefs, and to settle the matter definitely, a number of exhaustive tests were made, but in no instance was tellurium found.

1904. If I except some half dozen claims upon which sufficient was done to entitle the owners to a certificate of work, nothing has been done further to develop our quartz veins save what has been accomplished by Messrs. Baker and Atkin.'

Mr. Atkin says: 'The season was spent in still further checking the information gathered in the previous two summers, and the least promising properties were temporarily thrown up. Although there are many ledges which will well repay thorough and systematic prospecting, as soon as a railway lowers mining cost, it is unfortunate that none but the very richest veins in the country can be opened up under present conditions. The most important find of the season and one which may prove of great commercial value, was made on Hardscrabble Creek' (the finding of scheelite).

1905. If I except the undertaking by Messrs. Lasell and Hanour, two local men, to develop further the property of the British Columbia Milling and Mining Company, nothing worthy of mention has been done the past year. The persons mentioned, however, having secured an option on this company's property, caused the deep shaft to be baled out, when some 2 tons of rocks were extracted and sent out for treatment."

1906. A considerable amount of work was done on the veins of Proserpine Mountain by C. J. Seymour Baker, which resulted in the opening up of several new ledges, all of which appeared to be of low grade on the surface. The Forrest shaft was baled out and examined. Some quartz veins on Sugar Creek, Island Mountain, and near Stanley were also examined, but the highest value found was about $16 in gold to the ton and the galena ore 25 ounces of silver to the ton.

1907-1922. Either no mention of any lode mining or development in the Annual Reports, or only desultory and unsuccessful efforts.

GENERAL CHARACTER OF THE VEINS

There are two distinct types of quartz veins in Barkerville area, and the estimation of the possibilities of lode mining is inseparably bound up with the recognition and differentiation of the two types, and the working out of the relationships between them. These two types will be referred to as the A veins and the B veins. The A veins are very conspicuous features, but are not, generally speaking, liable to be of commercial value; the B veins are relatively insignificant features, but they constitute, especially near their intersections with veins of the A class, the only possibilities for lode mining in the area.

A Veins. This set of veins, constituting one of the most conspicuous features of the area, is the one to which the attention of prospectors and miners was directed in the search for the mother lode of the placer gold. The creeks contain many pebbles and the hill-sides are strewn in many places with large fragments of white quartz containing small amounts of pyrite, which are believed to have been derived from the disintegration and denudation of a belt of A veins that crosses the country from northwest to southeast. This belt varies from one-quarter of a mile to 3 miles in width. Longitudinally it has been traced from beyond Roundtop Mountain just outside of the southeast corner of the map-area to Sugar Creek just beyond the northwest corner—a distance of over 25 miles. Along this course, the belt of veins traverses Roundtop, Nugget, and Antler Mountains, Mount Burdett, Bald Mountain, Mount Agnes, Proserpine, Richfield, and Cow Mountains, Mounts Pinkerton, Burns, and Amador, and Island Mountain, and Mount Tom, to its most northwesterly known extension in Sugar Creek area.

The veins outcrop prominently on the grassy uplands of the plateau surface, particularly on the tops of Mount Burdett and Bald Mountain, where in places they stand as much as 10 feet in relief. There are very few, if any, regular, persistent, fissure-like veins in the belt; the individual bodies of quartz are usually discontinuous and lenticular, whereas the country rock in their immediate vicinity is well charged with small bunches and stringers of quartz of the same character. Single lenses or veins vary in thickness up to 200 feet, and may be followed by intermittent exposures, as on Mount Burdett, for distances up to a quarter of a mile. In general, however, the veins are composite, consisting of quartz zones with partings of schist, slate, or quartzite.

The trend of the belt of veins corresponds, as a rule, with the strike of the Cariboo series, since the veins themselves occupy compression fractures and zones of close folding and shearing developed during the formation of the main anticlinal structure. The strike of the individual lenses of quartz varies up to 25 or 30 degrees from the strike of the adjacent country rock, as shown by many observations recorded by Bowman, and their dips are usually steeper than those of the enclosing schists and slates. A general "*en échelon*" or step-like arrangement of adjoining lenses is suggested in a few places, but the exposures are not sufficiently good to establish this point. The veins are abundantly intersected by closely spaced fractures striking northeast, so that the quartz is exceedingly friable and tends to break into tabular sheets. In thin section, the quartz grains show a condition of intense strain, here and there resulting in fractures, but maintaining very striking, undulatory extinction. The stress to which the A veins have been subjected is emphasized by the occurrence of highly slickensided boundaries around the lenses, and the presence in places of black, graphitic schist, the foliation of which flows around the margins of the individual bodies of quartz.

Pyrite is the only metallic mineral that occurs in noticeable amounts in the A veins. It is irregularly distributed through the quartz in cubical crystals or granular masses; in some places it constitutes as much as half of the volume of the vein, but in the majority of places the quartz is characterized by its absence. The country rock in the vicinity of the pyritized veins is generally richly studded with pyrite crystals, which on oxidation have produced the characteristic brownish yellow coloration. The gold content of the pyrite in the A veins and adjacent country rock varies from a mere trace up to $10 to $12 a ton of pure mineral. Higher assays than these have been reported,[1] but it is not apparent whether the more auriferous pyrite was derived from the A veins themselves, or from

[1]*See* various reports of the Minister of Mines, B.C., 1876-1895.

localities in which A and B veins intersect. Very little reliable information is available concerning the actual gold values of the A veins. It is well recognized by those who have mined the quartz that no free gold has been found, or is to be expected, after the bottom of the belt of oxidation has been reached, so that whatever gold the veins contain is inherent in the pyrite. Small amounts of finely crystalline gold may be washed from the oxidized and rusty parts of the veins.

The following are typical examples of A veins:

(1) The mine of the B.C. Milling and Mining Company at the watershed between Stouts Gulch and Lowhee Creek. (For description, *See* page 41.)

(2) The large "blow-out" of quartz exposed in the hydraulic pit in Stouts Gulch, above the wing-dam. It is uncovered for a width of 50 feet and a length of 150 feet, and contains irregular bunches and disseminations of pyrite.

(3) Quartz ledges on top of Mount Burdett, 7 miles south of Barkerville. Some of these are continuous for one-quarter to one-half mile, and are up to 200 feet wide. Only very small amounts of pyrite can be seen in these veins.

(4) Quartz ledges which outcrop on the plateau of Bald Mountain, of the same general character as the last, but not so large.

The discontinuous and brecciated character, the "*en échelon*" arrangement, and the occurrence of elongated or lenticular bodies of quartz in zones of shearing in the Cariboo series suggest strongly that the quartz was deposited during the early stages of the development of the anticlinal structure and that its deposition continued through that period of deformation. The more regular, unsheared masses represent deposits during the later stages, whereas those zones showing marked "*en échelon*" structure are products of the early stages of deformation. As stated above, in very many places quartz stringers of the A vein type occur in and adjacent to sills of Proserpine quartz porphyry; and this fact, together with the occurrences of sheared and unsheared sills, suggest a genetic relationship between the A quartz and the Proserpine sills.

B Veins. The B veins are quartz-siderite-ankerite fillings of the northeasterly trending cross-range fissures and faults, and although they are, relatively to the A veins, inconspicuous features of the geology on account of their narrowness, they are important features because of their mineralogy and abundance.

Northeasterly trending fissures and faults occur in all parts of the area and cross all the bedrock formations, but only where they are found cross-cutting the Cariboo series and the Proserpine sills are they mineralized with quartz and metallic sulphides. The resulting veins vary in thickness from a fraction of an inch up to about 5 feet, and there are very many of them over a foot thick. Their average strike is north 25 degrees to 35 degrees east, but a few of them strike nearly north, whereas others trend north 60 degrees to 65 degrees east. As a rule they are quite continuous along their strike, as far as can be judged from their relatively unsatisfactory exposures. They are characteristically cross-faulted, so that each vein contains several minor sidewise offsets of a few feet, but none of these is of sufficient magnitude to interfere with the general continuity and exploration of the vein. In many places, B veins occur in closely-spaced parallel groups cutting across the foliation of the members of the Cariboo series, as at the Black Jack open-cut on Williams Creek, where twenty-five of them from 2 to 10 inches thick were counted in a total width of 50 feet. The fractures in which the veins occur not only traverse the Cariboo series, but pass through the A veins, and produce in the latter the cross-vein, sheeted, or platy structure commonly seen in the A quartz.

The minerals of the B veins are quartz, siderite, and ankerite, with galena, arsenopyrite, pyrite, scheelite, and minor amounts of sphalerite, and pyrrhotite. The quartz is not sheeted or platy like the A type, and has not been subjected to the same intense shearing stresses. Arsenopyrite and galena occur in many of the veins in considerable quantities, and scheelite is commonly disseminated in grains or collections of grains as large as walnuts, especially in the northwestern and southeastern parts of the area. Pyrrhotite was found to be sparingly present in a few of the veins in the Mosquito Creek hydraulic pit; sphalerite has been recognized from some of the B veins on Proserpine Mountain.

Both the arsenopyrite and pyrite are auriferous. Assays of selected material show the pyrite to carry as much as $10 to $12 a ton; the arsenopyrite contains gold values as high as 140 ounces a ton of pure mineral. (For details of these samples, *See* description of ledges on Proserpine Mountain, pages 42-52.) The galena contains on the average about one-half ounce of silver to the unit of lead.

There are three distinct types of structures in the B vein: (*a*) an undeformed type in which on each wall there is rooted a comb of quartz crystals, up to 2 or 3 inches in length, the space between the combs being occupied by siderite, ankerite, granitoid galena, or arsenopyrite; (*b*) an undeformed type, in which each wall is coated with layers of granitoid siderite or ankerite, the central part of the vein being filled with quartz and metallic sulphides; and (*c*) an autoclastic type resulting from the brecciation and subsequent cementation of the first two types. The autoclastic structure is also characteristic of the intersections of the A and B veins.

The development and relationship of these three vein structures are believed to be explained as follows:

(*a*) Some of the cross-range fissures which were formed following the first folding of the Cariboo series were mineralized with quartz, which was deposited as a series of crystals growing on the walls of the veins and forming the comb structure. A later deposition of siderite, galena, arsenopyrite, pyrite, etc., filled the middle parts of the veins, and produced the first undeformed type mentioned above.

(*b*) Later cross-range fissures did not receive the same early mineralization with quartz and the development of the comb structure. Their first mineralization was with siderite, galena, arsenopyrite, pyrite, etc., in granular structure; which corresponded in time and character with the filling of the middle parts of the first type of B veins.

(*c*) The reopening of both of the above types after the post-Mississippian period of folding, accompanied by a shift of one wall over the other, caused the development of the autoclastic structure, and produced veins of the third type mentioned above.

The autoclastic type is a very common one in the veins. Quartz, siderite, ankerite, and arsenopyrite occur in angular fragments cemented by foliated galena, whose lines of flowage wave around the other minerals, just as mica flakes appear to flow around pieces of quartz and feldspar in gneisses and schists. A shearing of one wall over the other, owing to a reopening of the vein, has apparently broken some of these quartz crystals loose and caused them to rub against one another, resulting in the grooving of their boundaries and the rounding of their angles. During the shearing the galena flowed, took on a foliated structure, and was rubbed, so to speak, into the grooves on the abraded quartz crystals. Where the abrasion of the quartz crystals has been extreme, they resemble grooved pebbles embedded in foliated galena. In other places, where a granitoid rather than a comb structure originally characterized the vein material, the sheared product consists of worn and rubbed fragments of quartz with vein-like cements of foliated galena. In these cases, the galena is not a later deposition in a brecciated quartz vein, but owes its vein-like crosscutting character to flowage.

The sulphide minerals in the veins are oxidized for various distances below the surface. The limited development of the veins prevents the presentation of any reliable conclusions regarding the greatest depth of oxidation, but it extends at least to 30 or 35 feet. Most of this oxidation, as shown in the subsequent section dealing with the origin of the gold, is an uneroded remnant of the Tertiary belt of weathering, which escaped removal during the Ice Age.

So far as known no free gold occurs in the veins below the limit of oxidation. The free gold that characterizes the upper parts of the veins represents material released in Tertiary time, largely by the oxidation of the arsenopyrite transported downward along the vein and deposited from solution in the vicinity of the water table. This process is discussed in the section already referred to on the origin of the placer gold.

The following are typical of examples of B veins:

(1) The series of northeasterly-trending veins on the Proserpine surveyed claim, near its southwestern line, on one of which the old Forrest shaft was sunk to a depth of 60 feet. The veins vary in width up to 2 feet and are well mineralized with pyrite, arsenopyrite, and galena. (See sketch map of claims on Proserpine Mountain.)

(2) The series of northeasterly-trending veins on the Warspite and Tipperary surveyed claims on Proserpine Mountain. (*See* sketch map of claims on Proserpine Mountain.)

(3) The Beedy or Perkins ledge on Burns Mountain, about 2 miles east of Stanley (Van Winkle). Here there are several parallel, northeasterly-trending veins, varying in width up to 2 feet, containing pyrite and galena, with considerable free gold in the upper, oxidized parts.

(4) The scheelite-bearing veins of Hardscrabble Creek, 7 miles northwest of Barkerville. These are quartz-ankerite-siderite veins carrying pyrite, galena, and scheelite.

The B veins are believed to have been formed after the building of the anticlinal structure in the Cariboo series and before the deposition of the Slide Mountain series. This belief is based on the fact that the veins crosscut the schistosity and the zones of shearing of the Cariboo series, and are not mineralized with sulphides where the fractures extend upwards into the Slide Mountain series. After the deposition and folding of the Slide Mountain series, the tendency of the country to settle back reopened the B fissures, and the movement of one wall over the other brecciated the more resistant vein minerals, pyrite, arsenopyrite, quartz, and siderite, and forced the less competent galena to yield by flowage.

The metallization of the veins, including the formation of the gold, cannot be definitely attributed to the effect of any observed petrological agent, but the mineralogy and structure of the deposits suggest that the metallic minerals owe their origin to emanations from intrusive rocks, whose location is inferred to be at comparatively short depths below the lowest exposed member of the Richfield formation, and of whose presence there the Proserpine quartz porphyry sills may be a manifestation.

Intersections of A and B Veins. Shoots of sulphide minerals are observed in the field to occur in veins of the A type where the latter are intersected or met by a number of B veins carrying metallic minerals. The reason for the localization of bodies of such minerals at these intersections is not quite clear, but the following explanation is offered as a reasonable hypothesis. During the formation of the zones of shearing in the Cariboo series, veins of the A type were being formed. As the shearing stresses continued and became intense, the competent quartz veins and lenses, formed during the early stages of the process, yielded by fracture and the country rock yielded by recrystallization into schist and slate. As a result of the brecciation the quartz became permeable to the passage of solutions, whereas the newly crystallized schist and slate became relatively impermeable. Later on, when the tendency to form northeasterly fractures was dominant, it happened that it was easier to slice the A quartz across the strike of the vein than to slice schist and slate across the foliation and cleavage. The result of both of these periods of stress was to open up by brecciation and slicing the quartz of the A veins, thus very greatly increasing the surface area of quartz exposed to the solutions circulating along the B fissures. This increase of surface on the part of the shattered quartz may account for the development of shoots of metallic sulphides in the vicinity of these intersections.

The recognition of these shoots places a new significance on the possibilities of the A veins. It now becomes essential, before attempting to evaluate the possibilities of an A vein, to determine the locations of crossing sets of mineralized B fissures, in order to ascertain the probable frequency and size of shoots of sulphides. Since systematic cross-vein sampling below the belt of oxidation has not beeen carried out on the intersections, and since only a few of them are completely exposed, it is impossible to give any a priori statement regarding these possibilities. But the amount of arsenopyrite, usually with high gold content, and of argentiferous galena, may be used as an approximate index of the values to be expected in the A and B veins and at their intersections.

As examples of shoots of sulphide minerals at such intersections, the following cases may be cited:

The *Black Jack* is located on the southeast bank of Williams Creek at the mouth of Black Jack Canyon, at the south end of the town of

Barkerville. An A vein is here intersected by a large number of mineralized cross-fissures of the B type, which have formed a well-defined shoot (For details, *See* description of Black Jack prospect, page 40).

The *Independence-Kitchener* are adjoining claims situated on Proserpine Mountain, and located on part of the main belt of A veins. Quartz lenses of the A type are intersected near the boundary line of the two claims by narrow quartz-ankerite-siderite veins of the B type. Insufficient work has been done to show the extent of the shoot of sulphides, either horizontally or vertically, but the intersection of the vein systems and the impregnation of the A veins with typical B vein minerals is quite clear.

Several small open-cuts on the Victory property, which is also located on Proserpine Mountain, reveal veins of the A and B types. About 500 feet north of two open-cuts showing A veins, are two other open-cuts exposing exceptionally well-mineralized stringers of the B type. The intersection of the two vein systems on this claim has not been uncovered, but other similar occurrences lead to the inference that shoots of sulphides should occur here also.

CHARACTER OF THE VEIN GOLD

The vein or " quartz " gold, found in the upper, shattered, and oxidized parts of the sulphide-bearing veins, occurs in various sizes from very minute specks to pieces worth from $10 to $30. The latter size is not necessarily the maximum, but represents the largest recorded piece of gold derived from the veins during the course of their very limited development. Larger pieces may occur. Most of the gold, however, is fine, a considerable part being flour gold, and only a very few large pieces have been found.

The gold exhibits, to a more or less perfect degree, a crystalline structure somewhat resembling a mosaic. Some specimens show a distinct granular structure, due to the presence of a very large number of minute, gold crystal grains. The very fine gold is also crystalline. Individual crystals and crystal groups are common. Some of the crystals are nearly perfect, the common forms being the dodecahedron, the cubo-octahedron, the octahedron, the cubo-dodecahedron, and the tetrahexahedron. A small tetrahexahedron twinned on an octahedral face (spinel law) was found during the summer of 1922. Hopper-shaped faces indicative of rapid growth are common. One crystal aggregate, consisting of about a dozen dodecahedrons with hopper-shaped faces, having an arborescent arrangement and almost entirely enclosed in a mass of limonite, was obtained by the authors. The mass was about the size of a bean, and when found, only about three minute corners of the gold penetrated the envelope of limonite.

Hypidiomorphic crystals of gold are common. Angular pieces or fragments of quartz are frequently associated with the gold and much of the quartz is iron-stained. Spongy masses with a high degree of porosity are not uncommon, and many specimens consist of a fine-textured quartz-breccia, the fragments of which are held together by a cement or fracture-filling of gold. Leaf-like gold is very common, and appears under the microscope as if the leaves or flakes had just been removed from between walls of some other mineral, the rough fractures of which are preserved in relief on the sides of the leaves. Very many of the pieces of gold have a fine, columnar, and wire structure, apparently due to incipient crystallization.[1]

ORIGIN OF THE VEIN GOLD

The outstanding characteristics of the vein gold are: (*a*) its occurrence in the form of leaves or veinlets—acting as cement in fractured quartz; (*b*) its occurrence as crystals; (*c*) its limitation to those parts of the veins characterized by limonite. These characteristics definitely correlate the free gold with oxidizing conditions, and with deposition in those parts of the veins that are highly fractured and cavernous. Well-developed crystals and crystal aggregates, such as that of the group of dodecahedrons mentioned above, could only develop in open spaces, or in spaces filled with the soft products of rock decay, where they could take definite bounding faces, without interference from adjacent hard minerals. Vein-like gold, which is so common both by itself and as a cement in the quartz breccias, could only have been formed in zones of minute shattering of the quartz. Gold crystals and leaves or veinlets of gold may be formed in shear zones in quartz either near the surface or at considerable depths; but the limitation of the free gold to those parts of the veins in which limonite is characteristic, confined the possibilities of such occurrences in this area to fractured zones at or near the surface. The free gold, therefore, is genetically related to some set of processes which operated under conditions of oxidation near the surface.

The hypothesis which is here advocated as an explanation of the occurrence of the free gold is that the gold content of the unoxidized parts of the vein was, and still is, very largely, if not entirely, confined to the sulphides, mainly arsenopyrite and pyrite; that the oxidation of these sulphides under near-surface conditions released the gold, which passed into solution only to be precipitated in crystal and leaf form at short distances below in the belts of weathering and cementation.

The conditions necessary for the operation of such processes and for production of sufficient free gold in the veins to supply the placers would be: (1) deep weathering and disintegration of the veins and country rock; (2) the presence of solvents and precipitants for gold; and (3) sluggish transportation by the streams. These conditions are fulfilled in Barkerville area, which consists of a deeply dissected, high-level plateau, the uplands being composed of remnants of a plain-like surface of erosion. Streams that formerly flowed at or somewhat below this plateau level must have been sluggish, for they occupied broad, shallow valleys. The amount of material being carried by the streams was, therefore, small, and rock decomposition with solution of the constituents must have been the most important feature of the later phases of that cycle of erosion.

There is little definite information available concerning the agents of solution and precipitation of the gold in the veins of this area, but it is certain that this action has taken place. As shown by Emmons,[2] Brokaw,[3]

[1] Maclaren, J. M.: "Gold, Its Geological Occurrence and Geographical Distribution"; London, 1908, p. 19.
[2] Emmons, W. H.: "The Enrichment of Ore Deposits"; U.S. Geol. Surv. Bull. 625, pp. 305-308 (1917).
[3] Brokaw, A. D.: "The Solution of Gold in the Surface Alterations of Ore Bodies"; Jour. Geol., vol. 18, pp. 321-326 (1910).

and others, chlorine in the nascent state is the most important and efficient solvent of gold. Chlorine-bearing minerals have not been recognized in the veins, and there seems to be no reason for suspecting their presence. Except the possibility of the presence of chlor-apatite in the schists, quartzites, and dyke rocks of the area, the only other sources of chlorine that might be available would be the rain water, or salt (NaCl) derived from the limestones of either sedimentary series. Oxidation of the pyrite and arsenopyrite would afford a supply of sulphuric acid, which is an essential in the solution of gold. Manganiferous siderite, which on oxidation affords manganese dioxide, an important agency in the solution of gold, occurs abundantly in the veins. In this connexion, it is interesting to note that on Burns Mountain near Stanley, from which the largest recorded pieces of quartz gold have been derived, a deposit of bog manganese was found from which a random sample gave on analysis 21·7 per cent manganese. This manganese was no doubt derived from the alteration of siderite.

Minute quantities of the above-mentioned constituents might produce solvents for gold in amounts large enough to produce the results that have been accomplished, when it is noted that these changes occupied a very long period of time during which the country was being reduced to a plain. Semi-arid conditions, as is possibly indicated by the general absence of wood in the ancient gravels, would also be favourable for gold enrichment, as they would permit of deep weathering and a marked oscillation of the groundwater-level.

Agents for the precipitation of the gold are abundantly present as pyrite, siderite, and carbonaceous material in the veins. According to Brokaw,[1] the carbonates, calcite, siderite, rhodochrosite, rapidly precipitate gold from chloride solutions, and Emmons states that "siderite is particularly efficient probably because in acid abundant ferrous sulphate forms."

The gold is found under conditions that suggest that both siderite and pyrite were its precipitants. Several pieces of vein gold (and placer gold as well) show negative pseudomorphs of pyrite or cubical depressions from which the iron sulphide has been leached. Much fine gold occurs in the porous, honeycombed quartz from which pyrite has been removed, and specimens of the quartz from Burns Mountain were seen by the writers, from which finely crystalline gold could be removed by shaking or tapping the specimen.[2] Both of these cases are illustrations of the efficacy of pyrite as a precipitant of gold from solution in this area. Gold has also been found associated with the characteristic rusty negative casts left by the solution of siderite.

The occurrence of free gold: (1) as very fine crystalline dust in the negative casts of pyrite crystals and in the rusty fractures near the surface; (2) as cement in fractured quartz; and (3) as fairly large crystals and crystal groups, throws some light on the manner of its growth. These three types of gold are crystalline, and show distinct evidence of having been deposited from solution. No evidence has yet been found to prove in what condition the gold exists in the sulphides—whether in the native form as

[1]Brokaw, A. D.: "The Secondary Precipitation of Gold in Ore Bodies"; Jour. Geol., vol. 21, p. 256 (1913).
[2]Rickard, T. A.: Cites a similar case in "The Formation of Bonanzas in the Upper Portions of Gold-veins"; Genesis of Ore Deposits, Am. Inst. Min. Eng., 1901, p. 737.

very fine disseminations, in chemical combination, or in solid solution—but the fact that wherever found it is either in actual crystal forms or with a crystalline structure indicates strongly that it must occur in the sulphides in a state in which, on the removal of the sulphides, it is readily subject to solution from which it is later deposited.[1] The gradations in size between the fine, free gold and the larger mass suggest continuous growth of the gold by the addition of material from gold solutions. The occurrence of the cement gold is undoubted proof of the operation of the processes of solution and deposition of gold ending up with the healing of the fractures. Where a rich supply of gold in its original form, as in some of the arsenopyrite, is available, there seems to be no reason why the continuous oxidation of the mispickel and the removal of part of the gold in solution should not result in the gradual growth of fairly large, single masses of cement gold.

A satisfactory hypothesis of the origin of large crystalline masses and definite crystals of gold in the veins is based on the reasonable assumption that the main part of the enrichment took place prior to peneplanation, while the country was still somewhat rugged and semi-arid. Under these conditions the belt of oxidation above the groundwater-table would have had a considerable vertical extent, perhaps 100 feet or even more. On the oxidation of the sulphides and the solution of the carbonates, solvents would be provided for the fine gold. This gold, once in solution, would travel vertically downwards until reducing conditions were met with at the level of ground water or beneath it, and these would be deposited in crystalline form. This set of conditions would provide a relatively thick gathering ground for the gold solvents, and, on the other hand, a restricted locality in which deposition would take place. Were the level of the groundwater-table to remain constant until all the gold were leached from the suggested thickness of 100 feet above the water-table, the result would be the deposition of all this gold in a shallow, horizontal belt near the water-level. During this process of deposition large crystals, groups, and veinlets would develop by gradual accretion. The progressive lowering of the water-table with the reduction of the relief of the country would bring lower and lower parts of the sulphite zone into the belt of oxidation and force it to render up its content of gold. As the larger pieces of this secondarily deposited gold came within reach of surface erosive agencies through the mechanical removal by drainage of the oxidized overburden, they gravitated into the valleys of the late Cretaceous and (or) early Tertiary streams, there to form the first placers, which have since been worked over and concentrated to form the placers that occur in the bottoms of the deep, V-shaped valleys.

CHIEF PROPERTIES

It is difficult to present a comprehensive and well-balanced statement of the geology and potentialities of the large number of quartz veins and ledges that occur in this area. Many of the best-known ledges, on which considerable work had been done in the early days, seem to possess a

[1]In this connexion certain experiments by Liversidge are interesting, in which he produced filaments of gold simulating moss—and tree—gold by roasting auriferous mispickel; Proc. Roy. Soc., N.S.W., vol. XXVII, p. 1 (1892).

degree of merit that is not apparent in the newly-discovered ones, but there is reason to believe that this difference may be due to the lack of development of the latter.

Only small amounts of useful information could be secured from the present-day examination of the properties; so the writer has endeavoured to analyse the old reports and to select therefrom for presentation here those parts of the descriptions that contain seemingly important data. The source of these data is given in all cases, but no statement can be made regarding the methods of sampling the veins, or the care with which the samples were assayed at Barkerville.

The locations of some of the best-known ledges are shown on the geological map, but for the locations of the others the reader is referred to the portfolio, published by the Geological Survey, Canada, in 1895, containing Maps 364 to 371, descriptive of the principal auriferous creeks of the district, copies of which are still obtainable (1933).

Black Jack Ledge

The property consists of two claims, the Black Jack, a real estate claim, and the Black Jack Extension, a record claim (in all about 62 acres), located on Williams Creek at the south end of the town of Barkerville.

The workings consist of an open-cut 100 feet long, 30 feet deep, and 20 feet wide at the face, and a shaft 120 feet deep. The open-cut is half filled with debris, but a very good exposure of mineralized vein material may still be seen along one side of the cut, and along the face. The shaft is totally filled with water and debris.

The deposit consists of a shoot of sulphide minerals located at the intersection of an A vein with a series of parallel, mineralized B veins. Twenty-five of these crossing veins, from 2 to 10 inches wide, were counted in a total distance of 50 feet. The minerals of the B veins and of the intersection are quartz, siderite, galena, pyrite, and some arsenopyrite.

The following information is taken from the reports of the Government agent, from the old company's letter book, and the superintendent's reports. The company had a one-stamp mill on the ground, operated by an overshot water-wheel. Most of the hoisting was done by a windlass, but in 1892 a boiler and small steam hoist were hired. At the 42-foot level, the ledge is 5 feet wide. Two hundred and two tons from here produced $3,573.10, as follows: $932 or $4.61 a ton in free gold was caught on the plates, and 46 tons of concentrates were produced and treated at the Government Reduction Works, yielding $2,641.10 or $57.52 a ton. This represents a total average of $17.68 a ton from the 202 tons. At the 64-foot level, the ledge is 35 feet from the shaft and 7 feet wide; it was crosscut in 1890, but no stoping was done. Nine hundred and seventy dollars was recovered from the ore taken out, but there is no record of the tonnage treated. Between the 64-foot level and the 120-foot level, the ledge was apparently faulted. A crosscut from the latter level encountered a ledge 46 feet from the shaft. It did not look very promising, and, being out of funds, the company closed down "temporarily," but never opened up the workings again.

In 1892, 28 tons of run-of-mine ore was taken from the 64-foot level, which yielded $426—$113 of this being in free gold, and $313 from 5 tons of concentrates. This represents an average recovery of $15.18 a ton.

"It was evident that a very large loss was sustained in concentrating the ore, inasmuch as the assay value of the ore averaged from $70 to several hundred dollars per ton; yet the actual results were in many cases not more than $20 per ton. This became more manifest when the Cassel Gold Extraction Company, of Glasgow, obtained, by means of the McArthur-Forrest process, from a trial lot of average ore, upwards of $90 per ton . . . There is a large quantity of $15 ore in sight, but it is costing more than that to mine it and mill it." (Extract from Letter Book of Black Jack Company, July 29, 1892.)

"It was learned from one of the former officers of the company that about $7,000 in gold was recovered from the ore treated." (From Ann. Rept., Minister of Mines, B.C., 1902, page 109.)

Bonanza Ledge

This ledge outcrops near the divide between Lowhee Creek and Stouts Gulch at the site of the shaft of the British Columbia Milling and Mining Company. The ledge strikes north 45 degrees west and dips 60 degrees to 70 degrees northeast, and is 17 feet thick at the surface. It consists of banded quartz of the A type with a few thin slate partings and small amounts of pyrite. A large dump of barren-looking, white quartz with some nests of granular pyrite gives the only evidence today regarding the character of the vein penetrated in the deeper workings.

The following information regarding the character of the deposit is taken from the Annual Reports of the Minister of Mines of the years noted (the year and page in each case stated in brackets).

"The quartz at the shaft is from 25 to 30 feet wide, with a strike south 60 degrees west, and dip about 80 degrees to south, and it appears to be an interbedded vein in slate or schist. There is an incline and shaft down 170 feet, intersected at 110 feet by an adit level. At this level drifts along the vein were made, that easterly, towards Williams creek, being about 75 feet long with a crosscut, whereas that to the west was about 140 feet long with two crosscuts, and at a distance of about 130 feet in a winze was down 18 feet. Opposite the first crosscut a bore-hole was put down from the drift for 97 feet, and drill-holes were also put down from the surface, one at a point 500 feet east of the shaft for 130 feet, and another at 600 feet to the west of the shaft for 143 feet. All of these proved the continuity of the quartz, and also showed that the values varied in different parts of the length of vein, and that the shaft had been sunk near the eastern limit of "pay ore"; that is to say, that the vein to the east was poorer, whereas from the shaft westward the values increased. In the winze from the drift average samples assayed as high as $37, and in the western bore-hole good values were also found. This would seem to indicate that "pay chutes" are liable to occur in these veins, and that even though the past workings of many of the large ledges have not proved up paying ore, yet that further prospecting may discover chutes amply large and rich enough to be profitably worked (1902, page 110).

The quartz in this large vein carried from 4 to 5 per cent of sulphides, which on concentration are said to have assayed in making mill tests over $20 per ton, but so far all tests for free-milling gold have been very low, or $1.50 to $2 per ton, and in this large vein no pay chutes or special pay-streaks have yet been developed in the amount of work so far done (1897, page 474).

At 52 feet below the surface, the ledge is 22 feet wide; and assays of rock from this depth averaged $33 per ton (average of eight assays). On the surface the vein averaged $14 per ton. At the Victoria shaft on the same ledge, at the depth of 350 feet, the vein averaged $14 per ton. Assays ranged from $24 to $36 per ton from width of vein of 30 feet (1877, page 396).

The St. Lawrence Company, situated at the eastern extremity of the Big Bonanza, have run a cut across the vein. This portion of the lode has well-defined vertical walls, the vein matter, containing a small percentage of iron pyrite, lead, and blende, assays from $6 to $35 per ton" (1877, page 395).

Bowman adds the following:

"Mr. Forrest states that this rock was assayed in 1878, and was reported to contain $90 a ton, but that subsequently the assays were reported erroneous........ Some galena is found in the hanging-wall; in the foot-wall the ore is all pyrites" (Geol. Surv., Canada, Ann. Rept., vol. III, pt. C, page 32, 1889).

In 1912, R. R. Hedley sampled the Bonanza lode, and in reply to a letter of inquiry, gives the following notes:

"As I remember, from the many samples taken, the predominating assay result was about $1.80 in gold per ton. There was one shoot, all too brief, that carried about $10, and there were some about $3 per ton. This was a great disappointment to me, as an English report pointed to an average of about $15 if my memory serves."

Proserpine Mountain Ledges

Numerous ledges or veins occur on the top of Proserpine Mountain, which lies between Grouse Creek and the headwaters of Williams Creek. Some of these, as, for instance, those on the Proserpine, Proserpine West, Proserpine South, Proserpine East, and Wilkinson (real estate) claims, received attention and development in the early days of quartz mining, and continued to be developed to some extent by C. J. Seymour Baker and associates during later years. The veins on the remaining claims, Discovery, Hard Cash, Independence, Vimy Ridge, Kitchener, Tipperary, Warspite, and Britisher, were discovered by E. E. Armstrong, F. J. Tregillus, T. A. Blair, and P. Carey in 1916 to 1919. The work done on them constitutes the most recent exploration in the area, and afforded the best opportunities for the detailed study of the vein systems. The exploratory work on the various claims was done partly by the owners, in the nature of annual assessments, and partly by the Mining Corporation of Canada under a working bond which they held on several of the claims in 1919 and 1920.

The accompanying figures (Figures 2, 3a, and 3b) indicate the positions of the different claims and of the various open-cuts, shafts, etc. The serial numbers appearing on the figures are used to designate the individual workings in the following statements and in figures.

Victory Claim. 1. A small open-cut showing a B vein 6 to 8 inches wide, striking north 35 degrees east, and stringers 1½ to 2 inches wide of solid arsenopyrite with pyrite and galena.

2. A B vein 10 to 15 inches wide, striking north 55 degrees east, with pyrite, arsenopyrite, and galena.

3. Irregular bunches of quartz containing some pyrite and arsenopyrite.

4. Open-cut showing 9 feet of barren quartz of A type.

5 and 6. Small open-cuts with barren quartz on the dumps.

7. Open-cut showing 13½ feet of shattered white quartz of A type, striking north 52 degrees west.

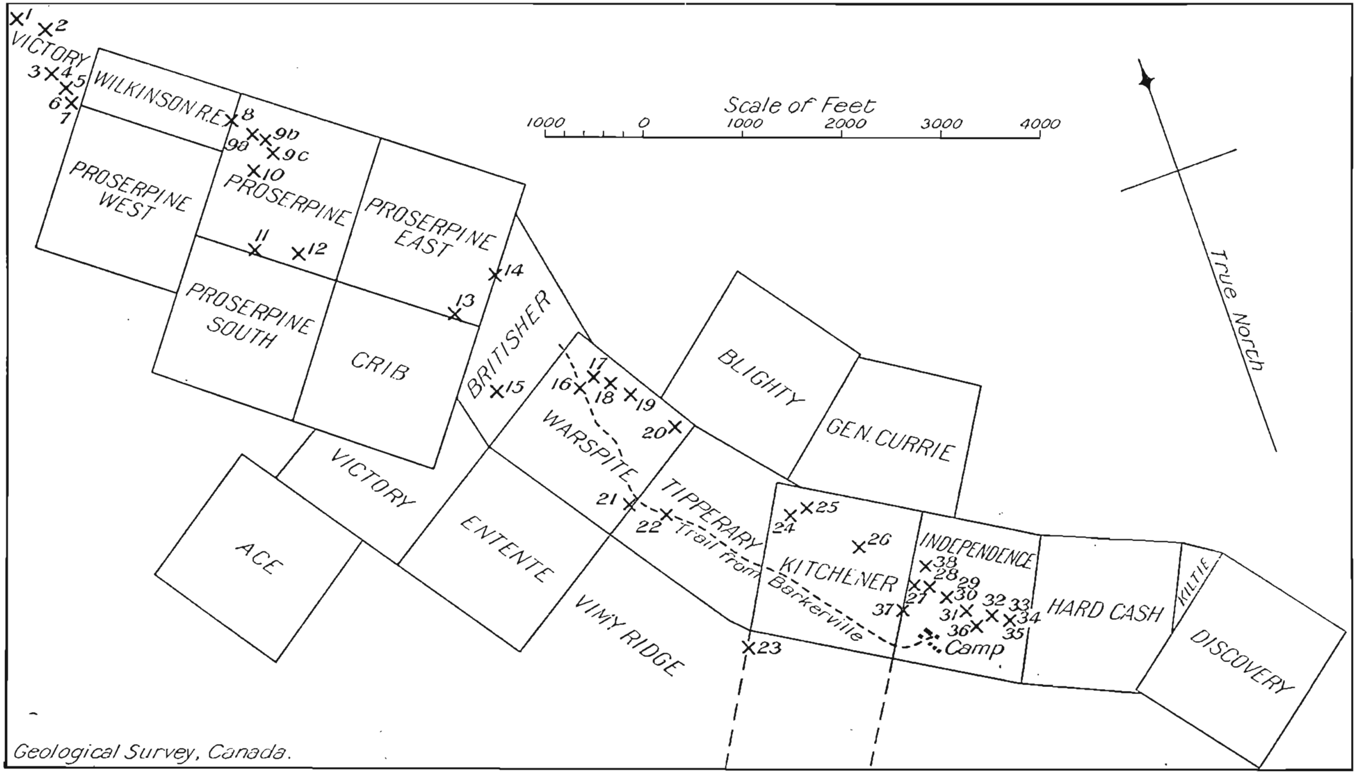

Figure 2. Index map showing principal mineral claims on Proserpine Mountain and location of workings described in text. (*See also* Figures 3a and 3b.)

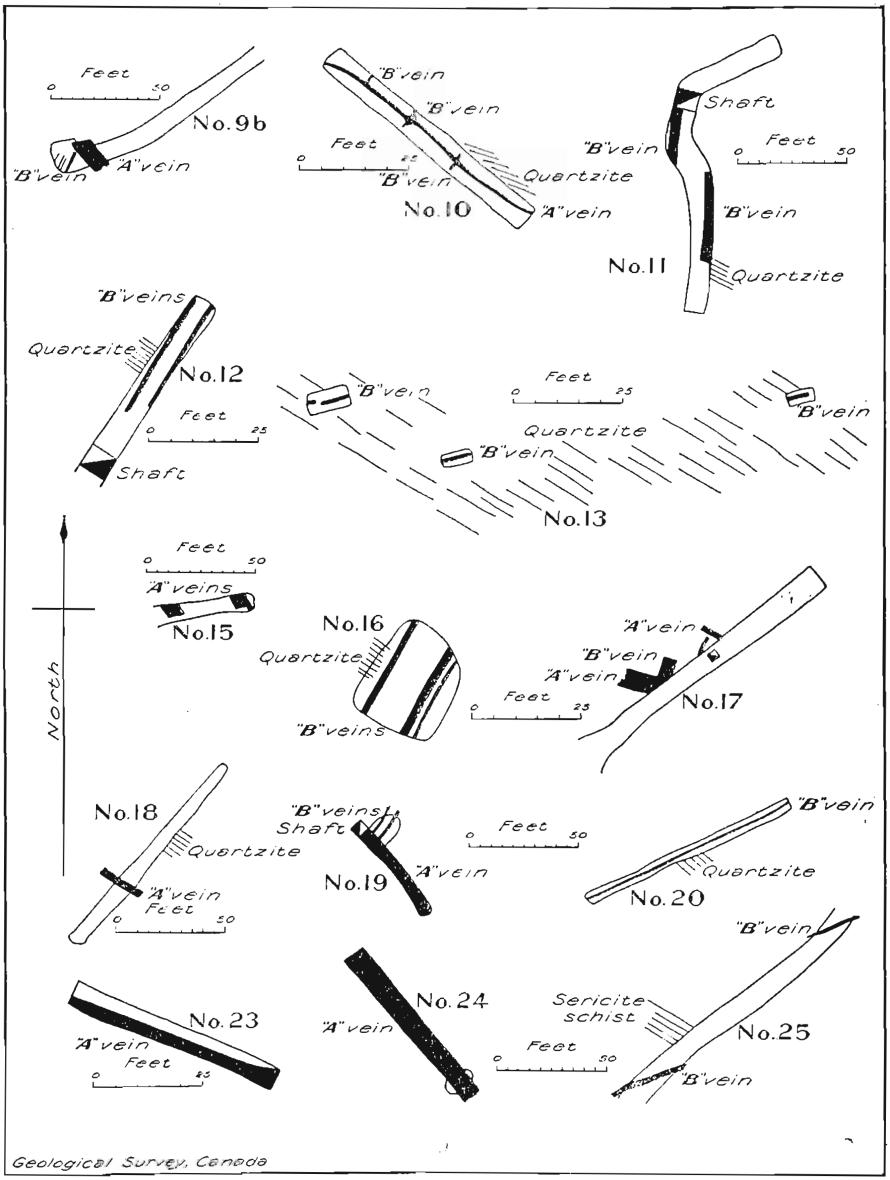

Figure 3a. Plans of workings on Proserpine Mountain mineral claims. (*See also* text and Figures 2 and 3b.)

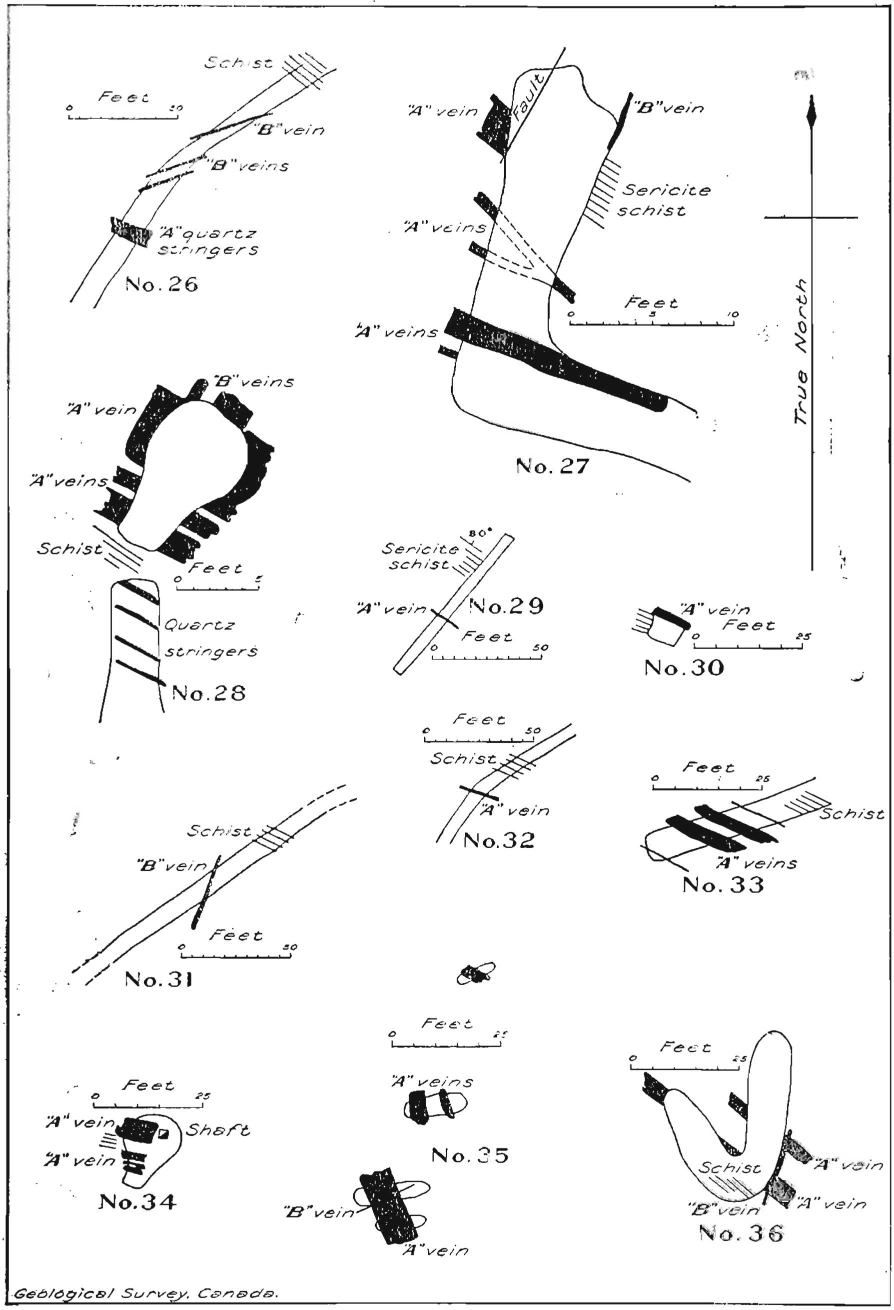

Figure 3b. Plans of workings on Proserpine Mountain mineral claims.
(*See also* text and Figures 2 and 3a.)

Wilkinson R. E. Claim. 8. Old shaft 50 feet deep, with large dump showing white quartz with small amounts of pyrite.

"On the Wilkinson there is an old shaft full of water and said to be 100 feet deep. Judging from the dump, this shaft was sunk almost entirely in quartz; this quartz carries a little iron pyrites and arsenopyrite, but is, for the most part, very barren-looking. Two surface cuts show the vein to be split up into quartz stringers occurring in slate" (1914, p. 66).

Proserpine Claim. 9 a. Old shaft 67 feet deep.

"From the inside of a cabin a shaft has been sunk 67 feet, and from this 100 feet of drifting has been done. This working was also full of water, but Mr. Baker says that throughout the vein is irregular and mixed up with the slate rock. To judge from the dump, very little quartz has been taken out. Two hundred feet to the southeast there is another old shaft 97 feet deep, apparently mostly in slate" (1914, page 66).

9 b. A tunnel 110 feet long and running southwesterly; 15 feet from the face it is crossed by an A vein, 4 feet wide, striking northwestward and well mineralized with galena and pyrite. Nearer the face of the tunnel in very rusty rock is a 9-inch B vein and several narrower veins of the same type, all striking northeastward.

9 c. Old shaft 67 feet deep.

10. An open-cut 60 feet long running northwest. Black, argillaceous quartzite striking south of east appears in the cut which is traversed by an A vein 18 inches wide in which no sulphides are visible, but which shows considerable limonite. Three narrow B veins at intervals of 10 to 14 feet strike northeastward, two of them cross and offset the A vein, the third touches the A vein but may not cross it.

11. A curving open-cut 150 feet long. The cut follows a curving, northerly course for 105 feet to where it bends to the northeast; at this bend there is a shaft 60 feet deep. From the south side of the shaft a B vein, 8 to 12 inches wide, carrying arsenopyrite, strikes south and is visible for a length of 30 feet to where it is intercepted by the west wall of the cut. To the east, 15 feet, along the east side of the cut, there is visible a B vein, 12 inches wide, striking south, dipping east at an angle of 80 degrees. This vein carries galena, arsenopyrite, sphalerite, and pyrite. It is exposed for a length of 45 feet. At the south end of its exposure it cuts quartzite striking south of east.

"The old Forrest claim which is now covered by the Proserpine ground, has an old shaft 60 feet deep sunk on a 4-foot quartz vein. At 40 feet the vein faulted up the hill, but was not followed. Mr. Baker pumped the shaft out and drifted a short distance on the fault and picked up the vein again. As usual, this shaft was full of water, but the vein is said to be 4 feet wide. Some of the quartz taken from beyond the break was lying on the dump, and of this a sample was taken which gave the following results: gold, 0·2 ounce; silver, nil. A number of open-cuts show the vein on the surface to be split up, with lenses of slate mixed up with it in an irregular way" (1914, page 66).

12. A long open-cut running about northeast. Quartzite striking south of east is exposed. A shaft (Forrest shaft) has been sunk in the bottom of the cut. Ten to 12 feet northeast of the shaft, two parallel B veins, 4 feet apart, are exposed for a length of 30 feet to the northeast end of the

cut. The veins strike northeastward. The northwest vein is 15 inches wide, the southeast vein is 12 inches wide, and both carry galena, arsenopyrite, and pyrite.

"Another vein, striking northwest, occurs on the Proserpine, and is exposed by an open-cut 100 feet long. This vein is also split into stringers, several of which are 1 foot in width; the total width, of quartz and schist, being about 10 feet. Mr. Baker has done some work on this vein, including a shaft 14 feet deep which was unfortunately full of water. Mr. Baker says the bottom of the shaft shows from 3 to 4 feet of quartz. The values are very spotted, but from numerous assays Mr. Baker says that the arsenopyrite mineral carried about 12 ounces of gold to the ton; the free quartz carries nothing; the iron pyrites nothing; and the galena 100 ounces of silver to the ton. The galena is of such infrequent occurrence that no importance can be attached to it. It would appear then, at least in this vein, that the occurrence of arsenical iron was necessary in order to ensure pay-ore. The writer did not sample any of the workings as there seemed to be little to gain by it. Mr. Baker has an assay outfit in Barkerville with which he has tested numerous samples, and he is, therefore, in a position to give reliable information in regard to values. Mr. Baker considers that his property carries sufficient value to make it a low-grade milling-ore, but unfortunately he has not sufficient capital to carry out the necessary development. The only way to determine anything definite about this vein would be to carry out some more work and thoroughly sample the whole of it" (1914, page 66).

Proserpine East Claim. 13. Three small open-cuts in quartzite striking southeast. In the westernmost cut, a B vein 15 inches wide strikes north of east, is visible over a length of 10 feet, and at the southwest end is offset a foot or so. The middle cut lies 30 feet southeastward from the westernmost cut, and in it a B vein 15 inches wide is visible from a length of 7 feet. The easternmost cut is 80 feet north of east from the middle cut and in it are visible fragments of a B vein. The quartz of the three veins contains galena and ankerite.

14. Two small open-cuts expose a set of irregular quartz stringers containing pyrite and arsenopyrite.

Britisher Claim. 15. A partly caved, short tunnel running eastward shows two A veins, one at the face and the other 35 feet from the face. Pyrite is abundant in the veins.

Warspite Claim. 16. A small open-cut in quartzite striking southwesterly. Three parallel B veins striking northeastward are visible from lengths of 20 to 25 feet. The westernmost is 15 inches wide; the middle one lies 10 feet to the southeast, is 24 inches wide, and carries arsenopyrite, galena, and pyrite; the easternmost vein lies 1 foot southeast of the middle vein and is 3 inches wide.

17. A tunnel 68 feet long and running northeastward. On the northwest wall 25 feet from the entrance a 4-foot A vein striking west-northwestward is intercepted by a 2-foot B vein striking east of north. In the floor, 38 feet from the entrance, a hole 18 inches deep shows quartz with pyrite. On the northwest wall, opposite this hole, is visible a narrow B vein, and on the same wall 42 feet from the entrance is a 14-inch A vein. From this point, for 26 feet to the face of the tunnel, mixed quartz, or quartz stringers and decomposed quartzite, are visible.

18. An open-cut 110 feet long running northeastward. Quartzite striking southeast is exposed on one side. An A vein 5 feet wide, without visible sulphides, crosses the cut with a northwest strike.

19. A shaft 31 feet deep. An A vein strikes southeast from the shaft; it is 6 to 7 feet wide at the outcrop and 12½ feet wide at the bottom of the shaft. Two B veins, striking southwest and 4 feet apart, extend to the A vein close to the shaft. One B vein is 18 inches wide, the other 10 inches wide. The A vein is mineralized with galena, pyrite, sphalerite, and some arsenopyrite near the junction with the B veins.

21. An open-cut now caved and full of water. A vein in the bottom is said to be 18 feet wide with schist partings. It consists of A quartz, calcareous with moulds of pyrite crystals; contains some foliated galena as seen on the dump.

Tipperary Claim. 22. A ledge of A quartz said to be 15 feet wide with schist partings. Quartz on the dump shows some pyrite. The quartz ledge is not now exposed.

Vimy Ridge Claim. 23. An open-cut 50 feet long running about north-northwest and traversed over its whole length by an A vein 7 feet wide at the southeast end of the cut and decreasing to a width of 3 feet at the northwest end of the cut. In quartz on the dump galena occurs in cross-fractures.

Kitchener Claim. 24. A vein of white quartz, at least 10 feet wide, outcrops for a length of at least 100 feet with a strike west of northwest. The walls are not exposed. The vein carries small grains and small stringers of galena.

25. An open-cut showing spotted sericite schist striking southeasterly. A B vein 18 inches wide carrying galena with sphalerite and striking about east-northeast crosses the southwest part of the cut. Ninety feet northeast a second B vein crosses the cut. It parallels the first vein, dips southerly at an angle of 65 degrees, and continues east beyond the cut for at least 15 feet; it contains siderite and galena along its margins.

26. An open-cut striking northeasterly and at its northeastern end showing spotted schist with a southeast strike. Towards the south end of the cut, a lode crosses with a strike of about east-southeast; it is 4½ feet wide and consists of mixed A quartz stringers and schist without visible sulphides. Thirty feet north-northeast a B vein, 12 inches wide, crosses the trend with a strike of about east-northeast; 5 feet to the north it is paralleled by a second B vein, 10 inches wide; 10 feet north of this is a third B vein 15 inches wide with galena in a brecciated part.

Independence Claim. 27. A tunnel that runs north-northwest for 12 feet, then turns at right angles and runs north-northeast for 20 feet. In places sericite schist striking about east-southeast shows on the walls. An A vein 10 to 16 inches wide follows the north wall of the entrance to the tunnel, with a strike of about west-northwest, and is exposed for a length of 13 feet. This vein at its junction with B veins shows abundant arsenopyrite, galena, and pyrite. In the west wall of the northerly trending part of the tunnel, and 1 foot south of the first-mentioned vein, is a parallel A vein 2 inches wide. Four feet north of the first-mentioned vein, a 7-inch A vein shows on the east wall. This vein forks as it crosses the tunnel; one branch with a width of 7 inches continues with a west-northwest course; the second branch runs about northwest, and on the west wall is 9 inches wide and is rusty. In the 2-foot space between the branches, the wall of the tunnel consists of black and brown gouge, and schist with some quartz. Three feet north along the west wall is a 2½-foot A vein with partings of schist and striking northwest. This vein is cut out by a fault running about east-northeast along the tunnel at this point. At the face of the tunnel, on the northeast corner, a B vein strikes north-northeast parallel to the above-mentioned fault. The B vein dips at an angle of 80 degrees to the west, is 1 inch wide, and holds galena.

28. An irregular pit, 10 feet long in a northeasterly direction, 15 feet deep in the larger part, and 6 feet deep in the constricted southwestern part. At the southwest end there is an A vein 18 inches wide, separated by a few inches from a 12-inch, parallel A vein to the north, which is separated by less than a foot from a 5-foot, parallel A vein in which the deeper part of the pit has been sunk. These A veins strike about northwest. At the northeast edge of the pit are two B veins striking at right angles to the A vein. One B vein is 8 inches wide and holds galena. It is separated by 1 foot of schist with pyrite, from the second B vein which is 2½ feet wide and carries galena and pyrite. Two feet south of the southwest end of the pit there is exposed 8 feet of mineralized schist with quartz stringers.

29. An open-cut 80 feet long in sericite schist. The cut runs northeast and is crossed at right angles by an 18-inch A vein.

30. A small pit in schist and shows 1½ feet of quartz lenses and soft, black gouge, separated by 2 feet of schist from 1½ feet of intercalated quartz stringers and rusty schist lying along a 2-foot, rusty A vein. The vein, quartz stringers, etc., strike about west-northwest.

31. A long open-cut crossed at one place by a B vein following a north-northeast course. The vein is 18 inches wide and contains siderite and some cerussite.

32. A long open-cut crossed by an A vein striking east-southeast. The vein is 10 inches wide, and consists of rusty fractured quartz with galena in the middle part of the vein.

33. A tunnel driven west-southwest in schist striking southeast. Fifteen feet from the entrance is a 3-foot zone of mixed gouge and rusty bunches of quartz. This zone is followed by a 3-foot A vein with partings of black and rusty schist. This vein to the west is bounded by 18 inches of mixed gouge and rusty bunches of quartz, beyond which is a second A vein, 3 feet wide and rusty. It is bounded by a 6½-foot zone of mixed, rusty quartz and schist extending nearly to the face of the tunnel. The veins and zones are parallel and strike about southeast.

35. Four small open-cuts along a south-southwest line. At the northernmost cut is exposed a 3-foot zone of mixed, rusty quartz and mineralized schist striking about southeast. Forty-five feet south, in the second cut, are two parallel A veins, separated by a width of 3½ feet; they strike nearly due north, are, respectively, 2 and 4 feet wide, and contain no visible sulphides. Thirty-five feet south-southwest are two closely

adjoining cuts, one traversed by a vein 8 feet wide with an exposed length of 13 feet and striking about south-southeast. The vein is crossed by a narrow B vein carrying abundant galena.

36. A curved open-cut in schist striking southeast. An A vein 3½ feet wide is exposed intermittently over a length of 40 feet and with a southeast strike. In it are schist partings carrying pyrite and arsenopyrite. Seven feet to the northeast is a second parallel A vein, 3 feet wide. Several feet farther northeast is a 6-foot parallel zone of schist with quartz stringers. The two A veins are crossed by a B vein of uncertain width and in which galena is abundant.

Selective sampling of the constituents of the Proserpine Mountain veins was done by the writer, so as to arrive at some conclusion regarding the auriferous content of the primary minerals. The character and manner of selection of each sample, as well as its metal content, are given herewith, mainly for the purpose of assisting the quartz prospector and miner to estimate the possibilities of his quartz.

It should be remembered in connexion with almost all of the assays of samples reported in the Annual Reports of the Minister of Mines, and in Bowman's report on the "Geology of the Mining District of Cariboo," that only surface material was available for treatment; and that such surface material is liable to have an enrichment of free gold which will not continue down into the unoxidized zone.

Location of sample	Character of sample	Gold Oz. per ton	Silver Oz. per ton	Lead Per cent	Arsenic Per cent	Iron Per cent	Insoluble Per cent
Independence Working No. 37.	Fresh, white, unoxidized quartz taken from width of 10 inches across A vein. No sulphides visible....................	None	None				
Working No. 33.	Channel sample across 17½ feet of mineralized zone. Represents oxidized part of A vein...............	None	None				
Working No. 37.	Selected sample of relatively pure, foliated galena from B vein or intersection.................	None	34·45	77·20			
Working No. 27.	Channel sample across 15 inches of B vein, containing some rusty, broken quartz, and considerable galena, pyrite, arsenopyrite....................	0·06	2·36	7·60	1·74	4·98	
Working No. 27.	Selected sample of coarse, granitoid galena from dump..................	None	41·72	63·80	....	0·33	
Working No. 27.	Selected sample of relatively pure arsenopyrite from A vein or intersection with B veins.......	0·41	0·58	0·65	17·82	36·22	

Location of sample	Character of sample	Gold Oz. per ton	Silver Oz. per ton	Lead Per cent	Arsenic Per cent	Iron Per cent	Insoluble Per cent
Working No. 38.	Sample of relatively pure, coarsely crystalline pyrite in A quartz from dump at tunnel mouth. Distant from B veins....	Trace	None	....	....	44·83	
Warspite Working No. 20.	Sample of barren-looking white quartz from B vein. No sulphides visible..................	None	None	....	....	....	....
Working No. 20.	Selected sample from dump from same vein, showing arsenopyrite disseminated in quartz.	None	None	....	14·64	....	
Working No. 19.	Sample of pyrite crystals from dump at Warspite shaft, taken partly from quartz and partly from black, slickensided gouge	0·48	0·14	....	....	47·54	
Working No. 19.	Sample of granular pyrite and pyrite crystals, same as above................	0·05	0·05	....	....	14·15	71·15
Working No. 17.	Selected sample of quartz with fine, granular pyrite and crystals from junction of A and B veins....	3·70	0·75	....	....	26·04	42·54
Britisher Working No. 15.	Selected sample of relatively pure pyrite from dump..................	0·47	2·33	....	....	40·51	14·16
Proserpine Working No. 11.	Selected sample of arsenopyrite in quartz from B vein and dump at Forrest shaft...............	1·69	2·51	....	11·83	....	
Victory Working No. 7..	Chip sample across 11 feet of central part of A vein. Chip taken every 6 inches eliminating all sulphides...............	None	None	....	....	....	
Working No. 1..	Sample taken from dump, representing full width, 1½ to 2 inches, of B vein, heavily mineralized with arsenopyrite. Side of veinlet much coated with iron rust; contained in sample..............	9·88	2·20	....	10·20	....	
Working No. 1..	Sample consists of two pieces of material similar to last sample, which were ground, cleaned, and washed to remove oxides..................	13·54	3·37	....	4·43	....	

Grouse Creek Ledges

" About 6 miles east of Barkerville, where much mining was done in the early days, the cleaned bedrock is seen to be traversed in many directions by a network of veins, but at the head of the creek were seen some large ledges."

At the Fountain Head

"a tunnel has been driven a few feet in a large exposure, 4 to 7 feet wide, of broken, rusty, honeycombed quartz carrying iron pyrites and zinc blende, but in another tunnel, lower down, the vein was only 10 inches wide if this tunnel has really gone in far enough to strike this vein that here cuts the schists and slates.

'Lord Dufferin' and 'May Flower' are old locations farther up the creek on which a large vein of white quartz and a little pyrites crosses the creek. A tunnel on one side runs about 30 feet northwest along the vein, 4 to 7 feet wide, until it is cut off by a fault, and a tunnel to the southeast is in over 170 feet, following for part of that distance a wide vein of the same white quartz that cuts across the black slate. The vein appears near the face of this tunnel to be split up into stringers, or to have become very small, but the ground is concealed by the timbering. From a 10-ton test lot of this ore, Mr. Marsh is said to have got $7 to $8 per ton" (1897, page 474).

Island Mountain Ledges

The openings that were made in these ledges in the late seventies and eighties, mentioned below, are nowadays caved and full of debris, and very little information of any value can be derived from a surface examination of them. Veins of A and B types no doubt occur, but it is impossible to say to which class the individual ledges belong. Bowman gives some detailed information on each of the veins, but there is nothing in his descriptions important enough to warrant repetition.

"John's Ledge, the best known of the ledges mentioned, is that owned by the Island Mountain Mining Company. This company holds three Crown-granted mineral claims. On this property three tunnels have been driven. The middle tunnel is in about 200 feet, with several crosscuts, and follows a very irregular quartz vein, but with one good wall, in a direction about south 45 degrees west. This vein is really a succession of interbedded lenses, having a width of about 3 feet and connected by a series of stringers.

Another tunnel, 25 feet higher vertically and 100 feet to the west, also follows the vein for about 150 feet, with a crosscut to the left. In this working the vein appears to be split, and is cut off for a distance, but is again in sight at the end of the tunnel. In the crosscut the vein appears to carry nearly 20 per cent of sulphides, and the face of the tunnel about 5 per cent, and as the gold is largely contained in the sulphides, the values will vary in the same manner. No work has been done here for eight or ten years, but a number of tons of ore from these tunnels were treated in the company's mill at the foot of the mountain, and are reported to have yielded between $2 and $4 per ton in gold.

The Little Giant mineral claim is about 300 feet above and overlooking Jack of Clubs Lake, and on the same hill as the previously mentioned ledge. In an open-cut there is a 3-foot quartz vein, showing no mineralization and occurring in an altered mica schist, apparently interbedded, and with a strike south 60 degrees west. This showing was followed in by a tunnel, now caved near the mouth so that it could not be examined, but reported as 100 feet long and with the vein narrowing very much, but with sulphides coming in in a very considerable percentage.

Some little distance below this last was the main tunnel. This tunnel started on a stringer of quartz 9 inches wide which gradually widened to nearly 3 feet and this quartz was followed in for 100 feet, at which point it cut off. The tunnel was continued for 500 feet farther into the mountain, without again striking the vein. This last-mentioned tunnel is connected directly with the stamp mill by a horse tramway, 1,000 feet long.

About 600 to 800 feet along Willow River and 2 miles west of the mouth of Mosquito Creek, Allan McKinnon was working on two quartz locations, the Mystery and Little Chief. Many years ago a tunnel had been driven here into the hill for 60 feet, at which point it crosscuts a quartz ledge about 12 feet wide. This vein was of dull-looking white quartz, not showing any visible sulphides, but, as sampled by Mr. McKinnon, assaying $3 per ton in gold. The claim on which this old tunnel was run had been abandoned for some years.

About 50 feet vertically above the old tunnel and to one side of it, Mr. McKinnon has sunk a shaft 50 feet deep on and dipping with a vein of quartz. The shaft, for the first 35 feet is at an angle of 75 degrees, the last 15 feet being almost vertical. The vein followed is about 12 feet wide, of white quartz, and where crosscut shows that whereas the portion nearest the hanging-wall contains very low values, in that portion near the foot-wall they are very fair. There is undoubtedly a body of quartz here of considerable extent, and the returns so far obtained by Mr. McKinnon encourage him to expect that he may strike on a chute carrying gold values" (1902, pages 111 to 112).

Steadman Ledge

"The Steadman ledge, on the right of Williams Creek, just above Richfield courthouse, was one of the well-known quartz ledges of the district, but little or no work has been done on it for many years; and though it has been staked, it is not even located as a mineral claim now. There is here a well-defined quartz vein about 6 feet wide, having a strike south 70 degrees east and dipping nearly vertically, apparently following the strike, but not the dip, of the enclosing schist. The walls are well marked by a good clay gouge, one wall showing from 2 to 3 inches of solid iron sulphides, and through the length of the vein there is a 6-inch streak of red spar. This ledge was also exposed by the placer mining done in the creek.

Mr. John Pomeroy, who went with the writer to the ledge, reports that a shaft was sunk from 40 to 50 feet deep, but had now caved in, and that at the depth mentioned the iron sulphides were nearly as wide as the shaft and very soft. The ore was crushed in a small 5-stamp mill and a small gold brick was obtained, but the property never paid. A sample of these iron sulphides was taken from an open-cut on the surface and assayed, giving results of $20 in gold on average samples, so that it would appear that there is here a strong, true vein, but having low values (1902, page 110).

The vein matter carries a large quantity of iron, blende, and lead. Assays therefrom vary from $16 to $20 per ton (1897, page 396).

The Cariboo Quartz Mining Company have crushed 41 tons of ore taken from the Steadman ledge with an average result of $18 to the ton. This ore was taken from a cut in the creek, having a vertical depth of 18 feet" (1897, page 396).

Only a small dump and an old, filled open-cut are visible today, opposite the mouth of Walker Gulch.

Pinkerton Ledge

This ledge outcrops on the northern slope of Cow Mountain and, in a southeasterly direction, crosses Lowhee Creek, where it is exposed in the hydraulic pit. The old workings were inaccessible in 1922. Some surface work was being done on this ledge during the winter of 1922 by Charles F. Law, of Vancouver, and associates.

"Assays taken from the quartz underground average $37 in gold per ton, with a small proportion of silver. The ledge is about 23 feet wide, and the deposit seems almost inexhaustible (1877, page 395).

On Lowhee Creek a couple of quartz ledges occur, from which exceedingly high assays have been had, and in which a very considerable amount of free gold is sometimes visible. Mr. Seymour Baker had this property under bond and was doing a little work on it, practically sampling it, with results not obtainable for publication. As far as the quartz exposures could be seen on the surface, they appeared to be lenses, which in a very short distance ran into stringers. Mr. Baker, however, reports later that underground the quartz is more permanent and regular" (1902, page 111).

Enterprise Ledge

Bowman (page 34) gives the following description:

"One and a half miles west of the Bonanza watershed. Strike north 62 degrees west, vertical; body 8 to 10 feet. These ledges (Enterprise and Pinkerton) do not appear to lie in the extension of the Cariboo or Bonanza ledge. Contents: quartz, not containing any mineral visibly; remarkable for their perfectly polished slickensides."

Rainbow Ledge

This ledge is located on the east slope of Cow Mountain, overlooking Lowhee Creek, and is recorded in the name of A. W. Sanders. It has been prospected by two small open-cuts, which are not sufficient to reveal clearly the vein relations. The prospect seems to consist of a few shattered and disintegrated quartz stringers in decomposed and broken schistose quartzite of the Richfield formation. Only the upper, oxidized parts of these veins are exposed, but the outcrops are very rich in free gold, as shown by the following tests. In the presence of the writer two panfuls of broken, oxidized, clayey rock were taken from one of the open-cuts, and were rapidly and roughly panned without being crushed. The gold recovered in the two pans was highly crystalline, and, on weighing, was found to have a value of $1.97. Other panfuls were estimated to contain upwards of $2 each; others had very small amounts. The richness of the outcrops suggests that they overlie a series of well-mineralized B veins or intersections.

Perkins or Beedy Ledges

These are located on the southern slope of Burns Mountain at an elevation of 5,000 feet, and about 2 miles due east of Stanley. They were among the first ledges discovered in the area, and were worked by J. C. Beedy of Lightning Creek as early as 1878, when he erected a small quartz mill having a capacity equal to five ordinary stamps.

The underground workings have caved in and at the time of examination were full of water, so that no examination could be made. Messrs. Fuller and Hawes, of Stanley, who re-staked the ledges recently, cleared some of the old workings that were close to the surface; and from these, the following information was secured.

There are two parallel veins, about 50 feet apart, striking due north with dips varying between 90 degrees and 70 degrees west. One of them is exposed intermittently for 400 feet, and varies from 10 to 15 inches in width. The mineralization is sugary to brownish brecciated quartz of the B type with siderite, pyrite, and galena. Free gold can be seen in the brecciated quartz, and fine, crystalline gold dust can be shaken from specimens of honeycomb quartz from which pyrite crystals have been completely removed by oxidation.

The country rock is grey, sericitic quartzite and sericite schist of the Richfield formation, in a nearly horizontal attitude.

Bowman made the following report in 1887:

"Body (of quartz) from 6 to 18 inches, sometimes widening to 3 feet or more. There are several ledges of this sort near each other. Contents: quartz, with galena, ferric hydrate, and iron pyrites. The quartz is usually honeycombed from decomposition of the pyrite, resulting in dark brown, bluish, and blackish oxides. Accompanying the galena there are white and dirty yellow oxides. An assay by Mr. Hoffmann of quartz carrying a little galena, gave: gold, 2·625 ounces, silver, 3·033 ounces to the ton. Another, holding more galena, yielded: gold, 0·365 ounce; silver, 29·896 ounces per ton. Free gold shows in fine particles after roasting and washing. Development work consists of a tunnel about 300 feet long, and several shafts, 50 to 70 feet deep, with connecting drifts and stopes. Several hundred yards north of the Perkins shaft is the Laura ground, on one of the Beedy series of ledges which has been extensively opened by the Cohen incline" (page 38).

It is from these ledges that the largest pieces of quartz gold have been obtained. The values have been variously reported as between $30 and $120.

Hardscrabble Creek Scheelite Ledges

"The property known as the Hardscrabble Scheelite Deposit consists of two Crown-granted mineral claims; it is owned by a syndicate of six men, of which J. A. Macpherson, of Stanley, and D. McCaskill, of Vancouver, seem to be most heavily interested.

The claims are situated on Hardscrabble Creek, half a mile above the junction of this creek with Willow River. The property is distant about 16 miles from Stanley.

Hardscrabble Creek was worked in a small way for placer gold many years ago. In the course of the drifting operations, small pieces of heavy white and brown minerals were found in the gravel and also in small amounts in the sluice-boxes. This mineral was finally identified as scheelite. Later in the drifting operations, the scheelite was found in stringers in place in the bedrock; a drift in the bedrock was run and a shaft sunk for the purpose of exploring the scheelite deposit. This work was done some years ago and since then no further development had been carried out. Last year the workings were cleaned out and fixed by Mr. Macpherson, so that the showing could be examined.

Workings. Entrance to the workings is by a shaft 60 feet deep, from which a drift extends northerly for 153 feet. At this point a winze has been sunk to a depth of 20 feet and a drift run to the east for 49 feet. The main shaft is in gravel throughout, and the main drift north is in gravel for half its distance before breaking into solid rock..........

Ore-showings. The main showing of scheelite occurs along the first 15 feet of the east drift, commencing at the winze. The country rock is a schist, in places highly micaceous. The strike is approximately north 60 degrees east (magnetic) with a dip to the north. The east drift follows approximately the strike of the schist country rock.

The scheelite apparently occurs in irregular stringers and bunches. There would seem to be two main series or fractures, one striking north 60 degrees east (magnetic) with the formation, and the other north and south (magnetic). Of these, the latter would seem to be the more important and in all cases noted they cut the stringers running with the formation.

With the limited development work done and entire absence of surface exposures, it is difficult to ascertain the true strike of this scheelite-bearing zone. It would seem, though, that the schist had been slightly fractured in the first place along a line of north 60 degrees east (magnetic) and some quartz deposited in the fractures. Later this schist has been fractured along a north and south line, and in these fractures, quartz, calcite, and scheelite have been deposited. From these fractures some scheelite has been fed into the quartz stringers running north 60 degrees east (magnetic), this giving rise to the opinion that the scheelite zone followed the formation. More work is necessary to determine definitely the true strike of the zone.

In addition to the mineral already noted, a little pyrite and galena occur in the stringers, but not in appreciable amounts. Wolframite, tungstite, and molybdenite are said to have been found in the deposit, but none was seen by the writer.

The stringers are narrow, from 1 inch up to possibly 6 inches. In 12 feet of rock-matter six stringers running north and south (magnetic) were seen. The stringers running in the other direction are very irregular and are more in the nature of bunches.

The schistose and quartzose rock-matter between the stringers is said to carry a little scheelite, but this is not visible to the eye. A sample taken to determine this point, on assay, showed no trace of tungsten. It is improbable that the schistose rock carries any appreciable percentages in tungsten, so that from an economic viewpoint only the narrow stringers carrying scheelite need be considered.

Values. The small stringers carry small bunches of scheelite, which in places are pure mineral. Assays of these selected specimens would, therefore, give high results. If 6 to 10 feet of the scheelite-bearing zone were mined out, the tungsten content would undoubtedly prove to be quite low, although possibly sufficiently high to be economically worked. Selective mining and hand-sorting of the pure scheelite might yield a small production" (1918, pages 135 to 136).

"The deposit as revealed by the underground working appears to constitute a zone from 3 to 8 feet wide, following the northwest-southeast strike of the country rock, which is here much metamorphosed to a mica schist. Angus Macpherson, who had charge of the underground work, informs me that masses of practically pure scheelite were found, at times 50 pounds in weight.

The scheelite is coarsely crystalline, pink to brown where fresh, but buff to cream where weathered on the surface as found in the gravels. Along with the scheelite I observed, on examining the ore-pile, small quantities of canary tungstite, and from some of the operators I learned that wolframite had been reported. Besides these tungsten ores and the two main gangue minerals, quartz and ferruginous calcite, pyrite and galena occur in small proportions.

It would be very difficult to form a correct estimate of the proportion of scheelite contained in the zone of tungsten-bearing rock. Mr. Macpherson considers, as a result of assays made, that the whole belt carried about 8 per cent of tungstic acid. The 2 or 3 tons of ore which I saw were probably much richer, but, as far as I am aware, no satisfactory assay sample has been taken with a view to determining the richness of the belt as a whole, and since no ore has been milled or concentrated, such estimates may be very far from assays based on systematic sampling or concentrating."[1]

The workings of the Hardscrabble Creek deposit were inaccessible during 1922 and were not examined. Specimens taken from the dump showing vein and country rock matter, indicate that the mineralization is of the B vein type. This conclusion is somewhat confirmed by the above-quoted description of the property of J. D. Galloway.

Sam Montgomery's Ledge

Bowman (page 39) gives the following notes on this ledge:

"Quarter of a mile above Stanley. Strike (from information) about south 30 degrees east. Body, 2 to 4 feet . . . . at the timber shaft, about 100 feet farther up, a "rotten ledge" was uncovered, from 4 to 6 inches in width, which crossed the creek in the same direction. The diggers sunk into the rotten edge 4 feet, all along its course, and washed the loose stuff, which yielded the best prospects in the claim. Montgomery got coarse gold out of it, $4, $6, and an ounce ($18) in weight. About 600 ounces of the coarsest gold in the claim was taken out of this rotten ledge."

[1] From report on "Tungsten Ores of Canada," by T. L. Walker, Mines Branch, Dept. of Mines, Canada, 1909.

Home Rule Ledge

This occurrence is on Barkerville Mountain, half a mile west of the lower end of the town, at an elevation of 4,700 feet. The ledge is about 5 feet wide and consists of white, vuggy quartz carrying minor amounts of galena and pyrite. The country rock is a brownish-weathering felsite sill, largely replaced by siderite. Quartz occurs in irregular bunches and stringers in the same sill about 200 feet west of the main open-cut, but no continuous vein can be seen.

Of this ledge, Bowman (pages 32-33) has the following to say:

"The opening on this ledge is a hole less than 10 feet wide and deep, leaving the strike and dip uncertain . . . . The principal characteristic of the Home Rule is its abundance of mineral in the shape of galena, limonite, pyrite, and their oxides; in which respect, it is not excelled by any ledge seen by me in the district."

Foster Ledges

"The Foster mine, Chisholm Creek (which empties into Lightning Creek at the town of Stanley) has so far given the best assay returns, ranging from $120 to over $700 per ton. The vein on the surface is divided into three stringers, running parallel to each other . . . . A shaft has been sunk to a depth of 18 feet" (1877, page 396).

Recent stripping of these ledges by Messrs. Fuller and Hawes, of Stanley, shows that there are three of them striking north, dipping 65 degrees west, and varying in width from 4 to 6 inches. They are well mineralized with galena, pyrite, and sphalerite and show stains of copper minerals. The veins manifestly belong to the B class.

Hudson Group

The Hudson group is located on the southern slope of Roundtop Mountain, a few miles beyond the southeastern corner of the map-area. It is recorded in the names of Fred Wells and I. E. Moore.

The claims and main showings are at altitudes of 5,000 to 6,500 feet, but mostly up on the sparsely-timbered, grass-covered plateau, where the quartz ledges stand in relief. The country rock is the sericitic quartzite of the Richfield formation.

Both A and B types of veins occur, but, owing to a covering of snow at the time of the writer's examination, the vein structure of the property could not be worked out. The approximate trend of the zone of mineralization appeared to be north 25 degrees to 35 degrees west. One zone of quartz ledges varies in width up to 57 feet, and consists of mixed quartz lenses, veins, and stringers and mineralized sericitic quartzite and sericite schist. Some of the smaller veins, evidently of the B type, contain siderite and ankerite with disseminated galena. A few shovelfuls taken from the oxidized, iron-stained outcrops revealed on rough panning fine crystalline gold, coarse gold in quartz fragments, galena, and much fine-grained, buff-coloured scheelite. Sixteen samples taken from the property by Fred Wells during September, 1922, gave on assay an average value of $38 a ton in gold. Work was being prosecuted, by the owners, on this group during the spring of 1923.

Other Ledges

There are very many other ledges of quartz in the area on which information worth reporting was not available. Some of these are gold prospects, and others are new finds with very limited exposures.

Amongst those, which, for the above reasons, are not described are the Aladdin-Honest John claims on the east side of Stouts Gulch, the quartz ledges outcropping on the grassy uplands of Bald Mountain and Mount Burdett; ledges in the hydraulic pits of Stouts Gulch and Mosquito Creek; Westport ledge on Williams Creek; ledges on Antler Mountain and Amador Mountain; ledges in Lightning Creek, Davis Creek, etc.

For whatever data are available with regard to these ledges, the reader is referred to the Annual Reports of the Minister of Mines, B.C., from 1877 to the present, and to Bowman's report on the "Geology of the Mining District of Cariboo."

PLACER DEPOSITS

The gold placers or pay-streaks occur in five different ways:

(1) They occur in ancient stream gravels resting on bedrock and in many cases buried beneath great or small thicknesses of glacial drift. These placers are by far the most important in the area and constituted the rich pay-streaks in the beds of the creeks, that were mined out, for the most part, in the early days. The gold-bearing gravels on bedrock vary from a few inches to 10 or 15 feet in thickness, averaging perhaps 5 or 6 feet, but in places nearly all the gold is directly on, or in cracks and crevices in, the bedrock. This is especially the case in places where the gravels are loose, porous, and not clayey. Where the gravels are clayey and contain numerous partly disintegrated fragments of the country rock, the gold is likely to be scattered through them.

The gravels on bedrock consist of water-worn but somewhat angular fragments of the country rock and in many cases include large masses of rock known as "slide-rock," apparently an ancient talus. The gravels were usually described by the miners as "flat wash." They are characterized in places by the presence of heavy minerals and rocks as pyrite, galena, scheelite, and barytes. Residual gravels, that is, gravels consisting principally of a resistant rock such as quartz, are present only in very small amounts.

The pay-streaks on bedrock are best developed in the narrow, deep parts of the creeks and do not occur to any great extent in the wider, upper parts near the sources of the creeks, where valley glaciation has been very pronounced, nor are they very rich in the wide, deeply buried lower parts of the creeks. The pay-gravels, in part at least, were deposited in pre-Glacial time, but were reworked, to some extent, by stream action in Pleistocene time.

The gold in the rich pay-streaks was mostly coarse. It was referred to by the miners as "lead gold," by which was meant a mixture of well-worn, coarse gold and moderately fine gold. There is comparatively little very fine gold in the area. It was recognized even in the earliest days that the creeks containing only very fine gold in the surface deposits were of little value and that where only occasional pieces of coarse gold were found in the bedrock gravels the pay-streak was not likely to be profitable. The " leads " of gold in many cases " played out " upstream and if the lead or pay ended abruptly it was held that it might possibly be picked up again higher up the creek, but if it gradually disappeared, chance of finding further pay was considered small. These theories proved correct only with respect to a few of the creeks. The pay-streak ended abruptly on Williams Creek above the canyon and was not found again higher up, probably because the effects of valley glaciation were much greater in the upper part than in the narrow, lower part; consequently the gold deposited in the old valley bottom was almost entirely removed.

The pay-streak at one place on Williams Creek on the Steel claim above the canyon was described[1] as " a blue clay layer 6 feet thick, containing decomposed slate and gravel, the overburden being 8 to 18 feet thick." In the early reports there are many references to the discovery of a " blue lead " similar to that in California. The supposition that the origin of the " blue lead " was the same in both regions was probably based on the fact that in many of the Barkerville placer deposits the gravels, especially when disintegration of slaty rocks in them has rendered them clayey, are bluish because of the presence of unoxidized or deoxidized iron sulphides. The gravels where these are weathered or oxidized are red.

(2) Pay-streaks occur in places in gravels on the bedrock benches at various heights above the present creeks and in a few places in abandoned or partly abandoned stream channels high above the present creeks. Remarkably flat and well-developed rock benches buried beneath glacial drift may be seen on upper Cunningham Creek and along the south side of Slough Creek and at other places. The gravels overlying the bedrock on the benches are mostly, if not entirely, glacial gravels. Gold occurs in the gravels and on bedrock and is somewhat different in character, in place at least, from the coarse gold of the deep channels. It is fairly uniform in size and much flattened and worn as if it had been transported and sorted by powerful streams. The rock benches are clearly old stream channels, and were formed preglacially, or possibly in interglacial time, and some of the gold on the benches may be pre-Glacial. The benches and old stream channels above the present valley bottoms are nearly all confined to the present valleys and seldom cross the present drainage courses, although there are exceptions, as in the case of Guyet Creek described later, for the courses of the ancient and present streams are very much the same. The preservation of these old stream courses is a remarkable feature, when the effects of the glaciation are taken into consideration. They are evidently pre-Glacial in age and some pre-Glacial pay gravels may occur in them, although no exposures of these gravels are known in the district.

(3) Interglacial pay-streaks, that is, pay gravels overlain and underlain by glacial drift, occur at several places, the most remarkable and richest known being at Eightmile Lake. They occur in places on Antler Creek, in the lower part of Williams Creek, and in the bottom and benches of Slough

[1]Bancroft's "History of British Columbia," p. 496.

Creek. As a rule they are not sufficiently rich for drifting, but are of importance for hydraulicking and dredging. In most places they occur above a false bedrock of boulder clay well above the bedrock in the creek bottom. None of the pay-streaks in the bedrock channels are definitely known to be Interglacial in age, although a few may be. The gold in the pay-streaks was derived, for the most part, by stream erosion of the glacial drift in which placer gold had been included as the result of a previous advance of the glaciers. It is evident that the gold was mostly derived from the glacial drift, and only in small part from the bedrock, because the streams in Interglacial time were able to cut down to the bedrock only in a few places.

(4) Gold occurs in places in irregular masses of gravel included in the glacial drift, as at Eightmile Lake, and to some extent in glacial gravels filling the stream valleys in places. No pay-streaks or appreciable quantities of gold are known to occur in the boulder clay nor in the larger gravel ridges and irregular hills, nor in the moraines formed by the valley glaciers. Small amounts of gold, however, are probably scattered through such deposits. The gold in the glacial gravels does not occur in a definite pay-streak except in places in the stream channels. The irregular patches of gravel in the glacial drift which contain gold may be preglacial gravels, or glacial or interglacial gravels included in a later drift sheet. None was seen that differs much from the glacial gravels.

(5) The post-glacial or surface gravels have been deposited near the surface in the beds and along the benches of the present streams and were rich in gold only where they are of no great thickness and extend down to a false, but more commonly the true, bedrock. In the wide, lower parts of the creeks, fine or "flood" gold occurs on the bars and along the stream flats in places favourable for deposition of the gold as the result of alternate erosion and deposition by the stream. The gold occurs in a thin pay-streak near the surface and such deposits are of little importance in the area. Even in the early days the prospectors appear to have been well aware that the "flood" gold had been transported and that unless some fairly coarse gold occurs along with it on the streams, there is likely to be little gold on bedrock beneath the bars. The gold, in the surface gravels on the benches, in places in the area, is fairly coarse and the deposits have been mined at many localities. They are not extensive, however, and, as a rule, have not paid for mining.

DESCRIPTION OF THE CREEKS

The creeks of the area (Figure 4) mostly radiate from the central high part of which Mount Agnes forms the summit. In the following greatly abridged account the creeks are described in order from east to west and only the more important ones are dealt with.

The possibilities for placer mining in the area are mainly hydraulicking. In 1925, when Memoir 149 was written, dredging on Antler Creek was being undertaken by the Kafue Copper Development Company and was carried on for a few years, but although considerable gold was recovered the results proved disappointing in the end owing to the small extent of the

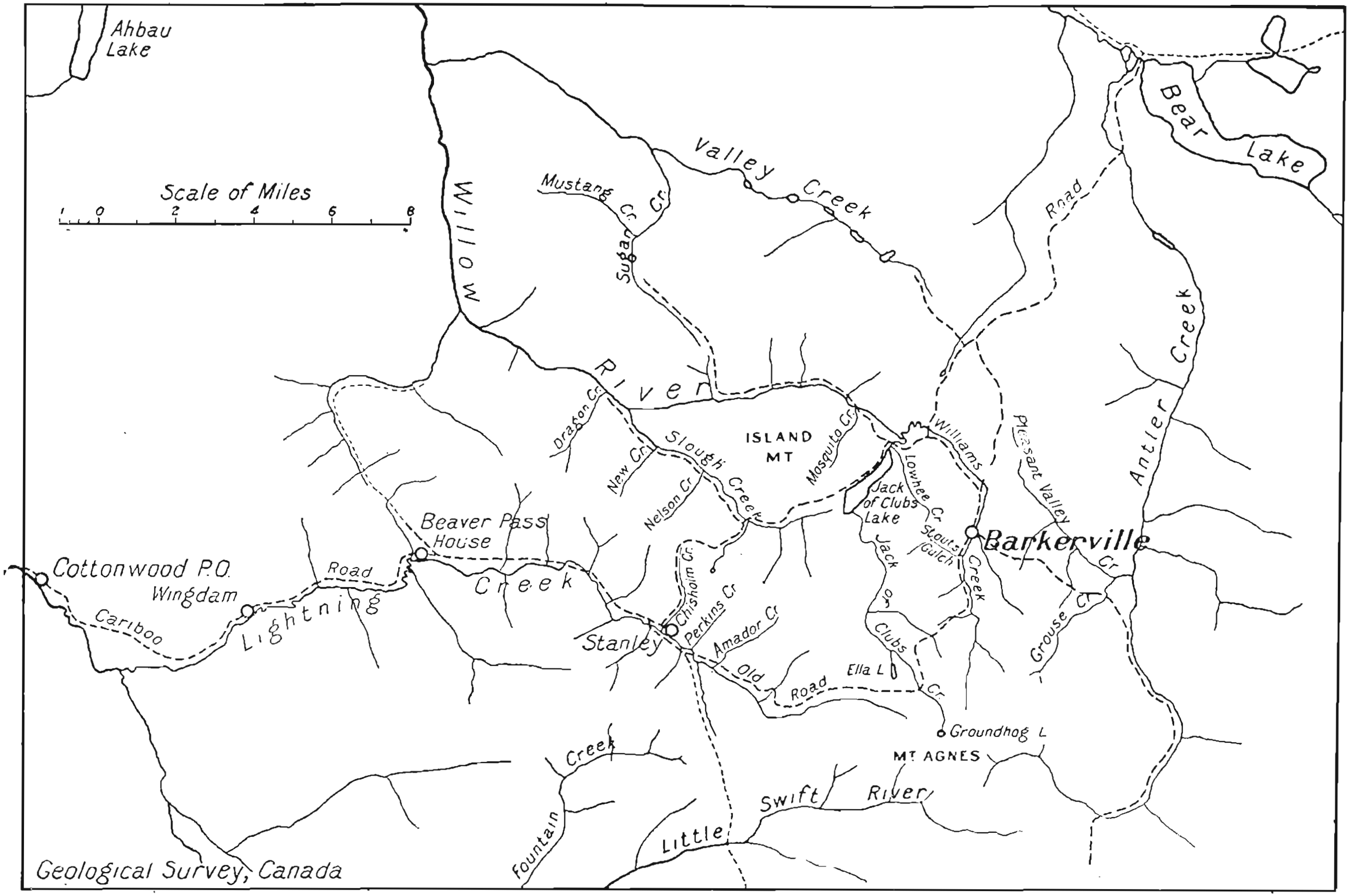

Figure 4. Barkerville district showing location of streams.

dredgeable ground and to the fact that parts of the rich ground had been mined by drifting in the early days. Since 1915 hydraulicking has been carried on by the Lowhee Mining Company on Slough Creek, at the Tre-house (Tregillus-House) mine on Cunningham Creek, at the Ketch property on Devils Lake Creek, at the Point mine on Slough Creek, and has recently been started again on the Waverly property on Grouse Creek. Placer mining has also been done at a number of other places. These operations are described in the Annual Reports and Bulletins of the British Columbia Department of Mines.

Upper Antler Creek

The part of Antler Creek above the mouth of Grouse Creek is usually referred to as Upper Antler Creek and the part below as Lower Antler Creek. Sawmill Flat, along which extends the old trail from Keithley to Antler, lies where Upper Antler Creek, after flowing southeast from its source in Bald Mountain, turns towards the north and the valley widens. The remarkably rich, gold-bearing part of Antler Creek, mined chiefly in 1861, extended down stream for about 1½ miles from near the mouth of Victoria Creek, the first tributary on the south side below Sawmill Flat. Between Victoria Creek and Sawmill Flat, Antler Creek occupies a narrow rock gorge along which little or no gold was found. The rich pay-streak thus ended abruptly. Below the old town of Antler, situated near the lower end of the rich ground, Antler Creek enters a narrow rock gorge, which continues for nearly a mile. Some gold was found along the rock benches bordering the canyon at about the level of, or somewhat lower than, the upper rich ground. There was little concentration, however, in the rock canyon itself. Below the canyon the grade of the valley bottom again lessens, the valley widens, and is partly filled with gravels which constitute the ground on the Nason and Lothair claims already described, dredged by the Kafue Copper Development Company.

Antler Creek above Sawmill Flat flows for the most part in a narrow, deep, V-shaped valley. The main tributary creek, Racetrack, occupies a broad valley which, in its lower part, known as Maloney flats, is partly filled with glacial outwash gravels and is flat-bottomed. Small amounts of gold were found in the surface gravels along Antler Creek at places between Sawmill Flat and the mouth of Racetrack Creek, but apparently little or none above this point. The southern branch of Racetrack Creek and the upper part of White Grouse Creek drain cirque-like basins, evidently due to glacial erosion. White Grouse Creek joins the main Antler Valley at the divide between Antler and Grouse Creeks and this divide is so low that the White Grouse water was easily diverted down Grouse Creek for hydraulicking.

Sawmill Flat extends south from the great bend of Antler Creek above Victoria Creek, for about 1½ miles, to a low divide at the headwaters of one of the branches of Swift River. At the lower end, the valley flat is about 400 feet wide and is floored with glacial drift and Recent alluvial deposits. Coarse gravels and boulders form the surface deposits near the lower end. At 1,200 feet up bedrock outcrops in the valley flat at the left side and the alluvial flat is narrowed to about 100 feet. A little gold is said to have been found in a shaft sunk by Jim Adams many years ago near the head of the flat, but no important deposits have been found. In 1902 Henry Boursin put down, by means of a horsepower drilling rig, a cross-section of three bore-holes on Swift River about one-half mile from Littler's cabin. The depths of the holes to bedrock were 31 feet 4 inches, 52 feet 7 inches, and 72 feet. He reported that gold was found in all the holes, but not sufficient to pay for mining.

Antler Creek above Sawmill Flat carries a good supply of water throughout the season, and water for hydraulicking at Maloney Flat, if the ground is found to contain sufficient gold values to pay, can be obtained by a ditch 1 to 2 miles long, depending on the head required. The creek has a fall of 140 feet from Maloney Flat to Sawmill Flat, a distance of 1,300 feet, and has a gradient of about 200 feet to the mile above Maloney Flat. The old China Creek ditch, in use up to 1915, leaves Antler Creek about one-half mile above Maloney Flat. It is about 140 feet above the flat, but is partly destroyed at places where it was flumed around the rock nose above the flat.

A well-marked, high-level channel parallels Antler Creek on the left side from the head of Wolfe (China) Creek south to the great bend of Antler Creek. It is about 400 feet above the creek and is followed by China Creek ditch. Bedrock outcrops on both sides of the valley at the reservoir about midway, near the summit, where the valley bottom is less than 100 feet wide. Near the south end the valley is drift-filled and the bedrock is probably lower than at the reservoir. The valley appears to have been formed, in part at least, by two streams flowing in opposite directions and heading near the reservoir, but has been modified by the effects of glaciation. It is, therefore, not necessarily an ancient high channel of Antler Creek nor the source of the gold found in the rich part of Upper Antler Creek. Shaft sinking and ground testing—to the extent of cleaning up about 100 square yards of the bedrock in the valley near the summit—was done about 1900, but apparently little gold was found. It was also reported that a tunnel driven into the right bank of the upper part of the China Creek hydraulic pit and a blind shaft at the end of the tunnel showed a channel in the bedrock extending upstream towards the reservoir. The valley has been again staked recently, partly on the strength of this report, but no further work has been done.

Antler Creek between Beggs Gulch and Wolfe Creek

This part of Antler Creek Valley is of interest chiefly because it is regarded by some of the prospectors as possible dredging ground. Drilling to determine this question has been carried on in several places. Nearly all of Antler Valley from a short distance above the mouth of Grouse Creek up to Cunningham Pass is a rock canyon averaging about 300 feet deep. The sides are not vertical, but are in most places too steep to be easily climbed. Numerous rock outcrops occur on the sides, but in many places the rock is covered by glacial drift and by rock or talus slides. The valley bottom in the part below the mouth of Beggs Gulch averages only about

150 feet in width and in a few places is less than 50 feet, though the bedrock outcrops in the bottom only at one place and this is below the mouth of Quartz Gulch. Above the mouth of Beggs Gulch the valley flat gradually widens and in the upper part is nearly 1,000 feet wide.

Drilling to determine the depths and gold values of the ground in the upper part near the mouths of Stevens and Wolfe Creeks was done by the Yukon Gold Company in 1915. A few borings higher up, just below the Nason ground, were subsequently made by the owners of the Nason and Lothair real estate claims and the half-mile lease below. In 1922 two borings, one near the mouth of Beggs Gulch and one 1,700 feet higher up, were made by the Cariboo Exploration Company organized by H. C. Foster of Calgary, Alberta, Alfred Brown of Barkerville being the driller. In the autumn of 1923 a number of bore-holes were put down in the wide part near the mouth of Wolfe Creek and near the mouth of Beggs Gulch, by W. E. Thorne representing the Kafue Copper Development Company. Three holes in the upper, wide part of the valley, one above the mouth of Wolfe Creek, one near an old sawmill site just above California Creek, and one in the bend of Antler Creek 700 feet below the mouth of Stevens Gulch, showed depths of 108, 125·5, and 80 feet. The last two were not to bedrock. The first two showed traces of gold. The material passed through was largely glacial silt and fine gravels. The hole near the mouth of Beggs Gulch was about 65 feet deep and showed fair values, but it was doubtful whether it reached bedrock, as there seemed to be large masses of slide rock near the bottom of the hole and the next hole higher up was considerably deeper. Three lines of bore-holes near the mouth of Beggs Gulch were put down by Mr. Thorne, Alfred Brown being the driller. Mr. Thorne stated that the average depth was about 85 feet and that the borings showed some gold. A line of bore-holes was also put down by Mr. Thorne about 300 feet above the old sawmill site at the mouth of California Creek where the valley flat is about 1,000 feet wide. The first hole alongside the road was a little over 100 feet deep and showed gold in the gravels for 24 feet above bedrock. Another near the centre of the valley was 147 feet deep and did not reach bedrock. It showed a trace of gold. There is apparently no boulder clay in the section bored, the materials being loose and porous gravels, sand, and silt of glacial origin.

Cunningham Creek

The headwaters of Cunningham Creek are in Snowshoe Plateau and Roundtop Mountain outside the area. The main creek flows north for about 6 miles to Cunningham Pass Valley, where it turns abruptly towards the east. The stream is one of the largest in the area and is larger, where it joins Cunningham Pass Valley, than Antler Creek opposite the upper end of the pass. The lower part of the valley is flat-bottomed for 2 miles above the junction, the alluvial flat of the present stream being from 300 to 500 feet in width, and has a surface gradient of 1·3 per cent. The sides slope fairly steeply and are drift-covered except near the upper end on the right bank. Here, the bedrock outcrops in the valley bottom and a series of remarkably flat bedrock benches 20 to 80 feet above the stream have been uncovered by hydraulicking. Lower down on the right side the drift deposits are terraced in places. Above the broad, flat-bottomed part of the valley the stream bends around a high rock hill on the left side. At the bend the valley bottom is narrow and the stream flows with a fairly steep gradient over bedrock. An artificial cutting, 6 to 13 feet deep, has been made in the bedrock for about 1,325 feet. Above the bend the valley widens for about one-fourth mile and a series of low rock benches only a few feet above the level of the creek occur on the left side. The rock in places on the valley flat shows glacial striæ and grooves formed by a glacier moving down the valley. Higher up, the valley is comparatively narrow and steep-sided. The bedrock is exposed in places in the valley bottom and on the sides, but for the most part it is concealed by drift deposits. The part of the valley below the junction is comparatively narrow and cut in drift deposits near the junction, but near the Bear claim below it widens out and rock outcrops occur in the valley bottom. Below the Bear claim the stream flows with a steep gradient in a narrow rock gorge. Well-defined benches cut in the drift deposits occur in places on both sides of this stretch of the valley, as well as in Cunningham Pass Valley above the junction, at various elevations up to 200 feet above the valley bottom.

The lower deep part of the creek from the bend down to the junction with Cunningham Pass Creek is of interest chiefly because borings have been made to determine the dredging possibilities of the ground and because of the hydraulic mining being carried on, on the benches along the right bank. The deep ground has been mined by drifting only at one place, near the lower end on the Victoria Company's ground. The Victoria shaft is said to have been 120 feet deep. In 1922, five bore-holes were put down by the Cariboo Exploration Company to test the value of the ground for dredging. The hole at the junction was 56 feet to bedrock; the one near the Victoria shaft was 95 feet deep and apparently struck the old driftings of the Victoria Company; the three holes 1,600 feet farther upstream were 33, 72, and 45 feet to bedrock. The channel is probably somewhat deeper between the second and third of these holes. The highest values, 33 cents a cubic yard, were found in the 72-foot bore-hole. The driller was Alfred Brown, of Barkerville, who supplied the information regarding the results of the borings.

The Tregillus hydraulic mine is located on the right bank of Cunningham Creek near the upper end of the wide, flat-bottomed part. The property consists of three leases totalling 4,500 feet in length and extending downstream along the right bank from a point about 200 feet above the lower end of the hydraulic pit. The benches higher upstream on the same side were mined by hydraulicking, chiefly by Chinese, for many years. The ditch owned by the Chinese miners was bought and operations begun at the lower end of the old pit in May, 1923. The deposits overlying the bedrock consist of surface gravels underlain by boulder clay and glacial gravels. Coarse gravels underlie the boulder clay in places and rest on the bedrock which is mostly hard and uneven, but shows no evidence of glaciation. The gold occurs in the surface gravels and in the gravels that lie underneath the clay and rest on bedrock. Comparatively little seems to occur directly on or in the bedrock. Some probably occurs in the gravels included in the clay, or as pieces scattered through the glacial clay. The gold is similar to what is usually described by the miners as " flaxseed " gold. It is fairly fine and uniform in size, but some large pieces occur. The property has the advantages of good facilities for the disposal of tailings and a fair water supply.

Grouse Creek

Grouse Creek heads with Antler Creek in Bald Mountain and flows north and northeast for 5 miles to Antler Creek. It is joined near Antler Creek by Pleasant Valley Creek flowing southeast. In the upper part, the stream flows for about 1½ miles in a deep, steep-sided valley along the sides of which the bedrock outcrops in many places, though it is mostly concealed by drift and by the soil and thick forest covering. The valley bottom is flat, and forms a beautiful alpine meadow such as is characteristic of the upland parts of many of the valleys. No gold was found in this part of the creek. About a mile lower down the stream turns abruptly towards the east, the valley widens, and rock benches mined for gold in the early days occur along the creek. Just below the bend a high, steep bank of glacial drift borders the stream on the right side for nearly a mile, down to the drift-covered flats through which the stream flows in its lower part. In the lower part the drift deposits are over 100 feet thick in places and very largely obscure the topography of the bedrock. A deep bedrock channel extending from the head of Quartz Gulch through the Waverly hydraulic pits, nearly at right angles to the general course of Grouse Creek, was almost entirely concealed by drift deposits before mining operations were undertaken, and was discovered by sinking shafts. The channel is comparatively narrow and steep-sided and averages about 75 feet in depth. In the lower part the bedrock channel is narrower and deeper than in the upper part and has been only partly uncovered by hydraulicking.

The New Waverly Hydraulic Mining Company, Limited, organized in 1918, acquired the property of the old company and attempted to mine the deep channel in the old Waverly pit and its continuation downstream by hydraulicking out a cut starting about 2,000 feet below the lower end of the old pit. In this attempt they were only partly successful, for although the outlet of the buried rock channel was found and was followed nearly all the way to the old pit it was found that the grade of the channel was low and the bottom of the channel was not reached. A great deal of work was done and a pit was opened up in three seasons which is nearly as large as the old pit. Although over 350,000 cubic yards of ground was moved by hydraulicking only a few ounces of gold was recovered. This is remarkable considering that colours of gold can be obtained almost everywhere in the surface gravels of Grouse Creek Flats. A hard mass of boulder clay was encountered at the bend in the channel 800 feet below the old pit and the deep channel lies beneath it. A tunnel was driven from the old pit to the draw leading to the new pit and the water stored in the pit was used for flushing. Bedrock outcrops in places on both sides of the draw and there is no doubt that the rock channel is the continuation of the channel in the old pit. It continues beneath the meadows at the head of the pit, to the upper part of Quartz Gulch, and is apparently an old channel of Antler Creek formed when the creek flowed at a much higher level and which has been deepened by headward erosion by a stream graded to the bottom of the present deep channel of Antler Creek. The upper part of the bedrock channel beyond the head of the old pit has a very low gradient. Two borings made in 1923 in the meadow 800 feet beyond the head of the old pit showed a maximum depth of 79 feet to bedrock and the ground may be somewhat deeper on the southwest side. The level of the bedrock in the bottom of the old pit, at a point 1,200 feet from the line of bore-holes, is about 17 feet lower. The bedrock channel between the two points, therefore, has an average grade of only about 1·5 per cent. The ground may be proved to be of some value for hydraulicking from Quartz Gulch, as one of the bore-holes in the cross-section showed values of 10 or 11 cents a yard. There is known to be some gold in the gravels in the bottom of the old pit, but whether in sufficient quantity to pay for mining is not known.

In 1922 drilling was done, in a channel leading from Grouse Creek to the meadows at the head of Quartz Gulch and behind the rock hill south of the road. A cross-section of six bore-holes was put down and a rock channel having a maximum depth of 30 feet was found, but there was no gold in it. About 12 feet of muck and timber (apparently an old beaver dam) were passed through at the top and boulder clay beneath.

In 1923, after a temporary suspension of work at the mine, gold was discovered in the waste water draw on the south side of Carey's draw, which lies between the main highway and the road leading to Waverly camp. Water was then brought on the ground by a pipe-line and as it was found that the bedrock dipped towards the south away from the draw, an hydraulic cut was started near the upper end of the old pit and extended upstream towards the new discovery ground for about 500 feet. Apparently little gold was found, and work was discontinued in 1924.

The water available for hydraulicking on the creek amounts on the average to about 400 miner's inches throughout the hydraulic season, assuming that the surplus during the freshet can be stored. The amount can be considerably increased by a ditch to Racetrack Creek.

French Creek

French Creek heads in a broad, deeply drift-filled depression connecting the valley of the creek with that of the upper part of Conklin Gulch and flows north into Pleasant Valley Creek. The valley of the lower part of the creek is so broad and so filled with morainic drift deposits, and there are so few rock exposures, that it is not evident where the main bedrock channel lies. In the upper part above where a small tributary joins it on the east side there is a marked increase in the grade of the creek and the creek flows in a broad, amphitheatre-like basin. High up on the sides of this basin the rock rims are exposed, but in the bottom the drift deposits are very thick. The grade of the creek is markedly uneven throughout its course. For 2,000 feet up from the junction with Pleasant Valley Creek the grade is 6 per cent. For the next 3,000 feet it is only 4 per cent, above which there is another sharp rise followed by another flat. The total fall in the creek from where it crosses the Barkerville-Grouse Creek road to the junction with Pleasant Valley Creek, a distance in a direct line of 9,500 feet, is 700 feet. As the depth to bedrock in the deep channel in the lower part is not known, the grade of the bedrock channel cannot be determined. In the dry season there is practically no water in the creek above the junction of the small tributary creek, and the flow at the mouth of the creek is very small. The average flow during the dry season probably does not exceed 10 miner's inches.

Mining on French Creek was carried on mainly in the seventies and several long tunnels were run. A pay-streak on the upper part of Conklin Gulch was traced a short distance towards, but not up to, the divide at the head of French Creek, and it was held that it might extend down French Creek. Several shafts were sunk near the summit and a long tunnel known as the Cosmopolitan was run in search of it. The tunnel starts at the level of the creek near the mouth of the main tributary stream and is said to end just above the road at the head of the creek. If so, the tunnel is nearly 2,700 feet long and at its upper end is about 250 feet under ground. The tunnel is said not to have reached bedrock except for some distance along a bench on the west side about 500 feet in from the mouth, and the gold recovered is said to have amounted to only about $2,000. Twenty-two hundred feet lower down on the creek there are two tunnels known as the American and the Revard. On the west side, opposite the mouths of the tunnels, there is an old shaft sunk by James Cummings in which pay was first struck on the creek. The American tunnel was run about 1871 and is said to have struck bedrock in the deep channel at about 1,300 feet upstream. Some gold, as much as 20 ounces to the set, but probably totalling not over $5,000, was found on rock benches along the sides, but there was apparently little or nothing in the deep channel. The Revard tunnel was run in the early nineties in search of rich ground which it was reported had been found but which could not be mined from the American tunnel. It is said to be 800 or 900 feet long and to lie partly in bedrock. It probably did not reach the deep channel and no good pay was found. The next tunnel lower down is the most recent one and was run by William Brown of Jack of Clubs Creek. It is only about 300 feet long and bedrock occurs near the surface on both sides of it. The deep channel probably lies on the east side and since it could not be reached with the tunnel except by cutting through the bedrock and extending the tunnel a considerable distance upstream the work was abandoned. Four hundred feet below Brown's tunnel there is an old shaft which may be over the channel and from which some drifting was done. At the bend in the stream 700 feet lower down, where a small tributary comes in from the east, there is another tunnel—the Clarke—which was run at about the same time as the American tunnel and is said to be about 500 feet long. The Pinkerton tunnel near the mouth of the creek is 400 or 500 feet long and is mostly near the surface and on bedrock. Scattered pieces of gold are said to have been obtained in running it, but no regular pay-streak was found. A shaft 500 feet west of the mouth of the Pinkerton tunnel was sunk by Joseph Wendle and Wm. Shilling about 1912. It was sunk 33 feet to water-level, but not to bedrock, and Mr. Wendle states that a good prospect was obtained in the bottom. Several test-pits were also put down near the mouths of the creek to depths of 8 to 12 feet and showed that some gold occurs in the surface gravels. The shaft showed that there is at least one deep channel near the mouth of the creek which is below water-level. There is sufficient grade for hydraulicking the surface gravels in the lower part of the creek if they are found to contain values high enough to pay, but the deep channel cannot be reached.

Conklin Gulch

Conklin Gulch flows from the southeast into Williams Creek at Barkerville and is the main tributary of Williams Creek. The road leading to Grouse Creek follows along the north side of the valley of the creek to the summit between it and French Creek, and the trail leading to Mount Proserpine passes up and crosses the creek in the upper part. The valley is comparatively narrow with fairly steeply sloping sides, except near the summit between it and French Creek, where it is broad and the sides gently sloping. It is drift-filled throughout, and only at a few places in the upper part is the bedrock exposed in the bottom of the valley and only rarely on the sides. The drift filling is especially deep near the junction with Williams Creek, where the ground is 90 feet deep.

The present creek, just above its junction with Williams Creek, flows in a narrow channel between rock rims a few feet above the level of Williams Creek Flats and bedrock above the level of the creek is exposed in the old hydraulic pit on the right side near the mouth. The deep channel, which is graded to the bottom of Williams Creek Valley, lies between the hydraulic pit and the present creek. The ground continues fairly deep for about 2,000 feet up from the mouth, where, as shown by old shafts, it is about 80 feet deep. Farther up, the depths are 48 to 60 feet and—above the broad part—20 to 50 feet. The gradient of the present creek for the first 4,000 feet upstream averages 7·5 per cent, for the next 4,000 feet 5·5 per cent, and for the upper part 7·5 per cent. The gradient in the lowest section of the creek is steeper in some places than in others, and it is said that the bedrock, both at about 2,000 feet up from the mouth and in places in the upper part, rises steeply almost in the form of a fall 10 to 30 feet high. The materials filling the valley consist of boulder clay at the surface near the mouth and along the sides of the valley, and glacial gravels and silt in the bed. Boulder clay, or silty clay containing scattered boulders, occurs in places beneath gravels in the bed of the creek for about 3,000 feet up from the mouth. Higher up the materials are mainly glacial, muddy gravels, but in places the clay extends down to bedrock. There are a great many limestone boulders in the valley, apparently because a limestone band trends in the direction of the creek.

The total length of the part of the creek that has been mined by drifting or the part that is known to be gold-bearing is 9,500 feet. Throughout this distance, measured in a direct line along the general course of the creek, the average gradient of the present creek is 6·5 per cent and the average gradient of the bedrock channel is about 6 per cent. There is thus a good grade for hydraulicking. A sluice flume brought up from Williams Creek on a 4 per cent grade would reach bedrock at a point about 3,000 feet upstream or about at the old Reid shaft. The deep ground at the mouth of the creek, of course, cannot be reached by hydraulicking. The amount of ground available in Conklin Gulch for hydraulicking and the average value per cubic yard cannot be determined, as no systematic testing of the ground by drilling has been done. The reasonable belief that the ground will pay for hydraulicking is based on the results of the shafts and test-pits put down by McDonald and on statements of the old miners that there were many places, especially along the sides of the creek, where gold values were found and the ground could not be mined by drifting because of the pressure of water and slum. The amount of ground will thus depend on how high up the sides of the valley the pay extends, and this, as well as the average value of the ground, can probably be most economically determined by systematic drilling. All the ground lies well below the Stouts-Lowhee system of ditches, the water of which brought around the head of or across Williams Creek by means of a syphon, may eventually be used for hydraulicking on Conklin.

Lowhee Creek

Lowhee Creek was discovered to be gold-bearing by Richard Willoughby in 1861. The creek is about 1½ miles long and drains into the meadows at the lower end of Jack of Clubs Lake. At the head of the creek there is a drift-filled channel which continues to the head of Stouts Gulch. Watson Gulch forms the main headwaters of the creek. The rock valley of the creek is narrow and V-shaped and the part that has been hydraulicked out, except near the lower end, was filled with glacial drift to an average depth of nearly 150 feet. In a few places there are rock benches on the sides of the valley and these, together with the shape of the bedrock valley, show that it was formed by stream erosion and has been modified only slightly by ice erosion, although it was filled with glacial drift. In places near the upper end of the part that is hydraulicked out the bedrock in the bottom of the channel is badly disintegrated and is altered to red and grey residual clay to a depth of 2 or 3 feet and for a width of 20 to 30 feet.

Placer mining on Lowhee Creek began in 1861 and has been carried on to some extent nearly every season since that time. Mining was first done in the shallow ground in the bed of the channel near where the creek flows into the Meadows. Here some remarkably rich ground was mined by Willoughby and others in the sixties. The ground gradually deepened above and the water pressure was a serious obstacle to drift mining, yet the difficulties were overcome and all of the channel, except for a short distance in the upper part, was mined by drifting in the seventies and eighties. Hydraulicking began in the nineties and was carried on for several years by the Cariboo Consolidated Mining Company, Limited. In 1906 the property was acquired by John Hopp and hydraulic operations have been continued each season since that time. The property at the present time is probably the best-equipped hydraulic mine in Cariboo. During parts of 1922, 1923, and 1924, the grade of the sluice-boxes in the upper 1,425 feet of the flume was changed from a 6-inch (to the 12-foot box) to a 5-inch grade and the wooden blocks throughout the flume were replaced by steel plates.

The water supply for the mine is brought by an extensive system of ditches about 26 miles in length and there are two storage reservoirs, Ella Lake near the head of Jack of Clubs Valley and Groundhog Lake at the foot of Mount Agnes. The Lowhee ditch comes from Ella Lake and extends along the west side of Lowhee Creek to Watson Gulch. In 1923 the ditch was extended to the head of Stouts pit and a new dam for a reservoir constructed on the summit 2,150 feet above the old dam. The old Gold Fields ditch, which forms part of the system, comes from the headwaters of Lightning Creek, and where it ends near the end of the Lowhee ditch is 100 feet above the latter. The water from the Gold Fields ditch runs into the reservoir on the summit and is used for a ground-sluice at the head of the Lowhee pit, where there is a vertical fall of about 80 feet. The Lowhee ditch is 7 feet wide at the top and 4 feet at the bottom and is capable of carrying 1,500 miner's inches of water. It has a gradient of 9 feet to the mile.

Eightmile Lake

Eightmile Lake is about 7 miles north of Barkerville and is reached by wagon road down Williams Creek and up Downey Pass Creek, or by the Bear Lake road to Pine Creek and thence by foot trail (formerly a wagon road) to the lake. The lake lies near the summit of a broad, drift-filled valley which extends northwest and is drained by Valley Creek. The lake itself drains to the east by a short stream flowing into Summit Creek, which, a short distance lower down, flows in a deep valley cut through the high range of hills, trending northwest. Slide Mountain, 6,350 feet high, is on one side of the valley and the Two Sisters, nearly 7,000 feet high, on the northwest side. The lake has an elevation of 3,981 feet. There is thus very considerable relief in the area to the east of the lake. The area in the vicinity of the lake, and between it and Pine and Shepherd Creeks, has a relief of only 200 to 300 feet, but the surface is very uneven because of the irregular deposition of glacial drift, and very few rock outcrops occur. The Thistle hydraulic gold mine, on the south side of the lake, is of special interest as one of the few important discoveries since the early days, and because the pay-streak is interglacial in age—that is, the pay-gravels are overlain and underlain by boulder clay deposited by glaciers. Other occurrences of somewhat similar character are known in the district, but none in which the pay-streak is so rich as it was at the Thistle mine.

The gold at Eightmile Lake is fairly coarse and uniform in size, and is much flattened and worn. The average colour is, perhaps, worth one cent, although occasional pieces worth as much as $11 have been found. Its character suggests transportation and sorting by a much more powerful stream than exists at present in the vicinity of the lake. The former stream came into existence, probably, as the result of melting of the ice. The pay-streak is known to extend beneath the south side of the lake where it is buried beneath tailings, but neither its total extent nor its value is known. The area beneath the lake and in the general vicinity of the pit appears to be well worthy of prospecting with the drill to determine whether there be sufficient ground of value to pay for dredging. It does not appear possible to mine the ground economically in any other way.

There are difficulties, however, in dredging, as the boulder clay above the groundwater-level is hard, and would probably require blasting to break it up; and there are numerous large boulders in the deposits—especially in the lower part near the contact of the two drift sheets.

Devils Lake Creek

This creek is traversed by the main highway and flows north into Slough Creek. It occupies a comparatively narrow, steep-sided valley. The valley sides in the upper part of the creek are mostly rock, but in places are veneered by talus and glacial drift. Three small ponds, in the upper part of the valley, occupy depressions formed as the result of rock slides partly blocking the valley.

The Ketch hydraulic mine is located on the right bank of Devils Lake Creek near its mouth. Tunnels run into the bank 50 feet above the level of the creek showed some gold on bedrock, and in 1921 the property was opened up as an hydraulic mine. Hydraulicking has since been carried on each season. Water is brought by a ditch from Burns Creek. Hydraulic work at the property showed that a narrow bedrock channel about 50 feet deep in the deepest part, 300 feet long, and 50 feet above the level of the creek, runs parallel to the canyon. It was filled with glacial gravels. These were hydraulicked out, mostly in 1923, except for a short distance at the upper end. A remarkable feature is that the bottom of the channel has a slight gradient up the valley of Devils Lake Creek. The mode of origin of the channel is not very clear. It may have been formed by a stream flowing along the ice which at one time partly filled the canyon, or it may be a remnant of an old rock channel formed before the canyon was eroded to its present depth.

Gold was found in the glacial gravels in the old channel and on irregular bedrock benches above the channel. The gold on the benches probably occurs on the bedrock and in gravels, small amounts of which occur in places beneath boulder clay. The clay is 20 to 30 feet thick and in places extends down to the rock. The gold is mostly fairly coarse and appears to be very irregularly distributed. It may be that it is partly scattered through the glacial drift. The fairly hard character of the clay, especially where it extends down to bedrock, renders hydraulicking difficult. The deposits overlying the bedrock, however, have no great thickness, the rock benches may extend for some distance along the valley of Slough Creek towards Burns Creek, and there are good facilities for disposal of the tailings.

Slough Creek Benches

A series of rock benches overlain by drift deposits occur along the south side of Slough Creek and extend from the mouth of Devils Lake Creek to Nelson Creek. In 1881, they were found to contain gold and since then have been hydraulicked chiefly by Chinese companies for nearly the whole distance. The first work was done near the mouth of Devils Lake Creek and near where an old flume crosses Nelson Creek and extends northeast to the benches of Slough Creek. Its course apparently indicates that the drainage of Slough Creek Valley was at one time the opposite of what it is now. The major operations in recent years have been carried on by the Point Hydraulic Mining Company, Limited, on the Point ground. Hydraulicking has been carried on for over twenty-five years at the Point mine, which was so named because of a high "point" of rock on the property.

Water is obtained from the drainage basins of Nelson, New, and Montgomery Creeks. The drainage area above the ditch is 90,000 square feet. This area furnishes an average flow of 8 cubic feet a second (285 miner's inches) throughout the hydraulic season. There are no large reservoirs available in the drainage basins, and the freshet water can not be conserved. This difficulty is overcome to some extent by using several pipe-lines and monitors in the pit during the period of high water.

The deposits overlying the bedrock on the benches consist of glacial drift and vary in thickness from a few feet to over 100 feet near the inner edge of the benches. The rock benches are fairly flat, but have numerous small irregularities and are cut through in places by stream channels, which, however, are only a few feet deep and are not graded to the bottom of Slough Creek Valley. The bedrock at the inner edge of the benches, where it is exposed near the upper and lower ends, rises steeply, and it probably rises fairly steeply all the way along the inner edge of the benches. The rock benches are much wider in some places than in others and the inner edge has been reached at only a few places. The deposits overlying the benches in the central and eastern parts consist mostly of gravels. In the western part they consist mostly of glacial silt and boulder clay. The clay, however, is overlain and underlain by gravels. On the western part of the Point claim there are, in places, two boulder-clay sheets separated by a few feet of deeply weathered, rusty, and partly cemented gravels, indicating a period of interglacial weathering and erosion, and probably also some concentration of placer gold. The gold is thought by the hydraulic men to occur mainly on bedrock, and especially in draws in the bedrock, but it is difficult to tell just where the gold occurs, for during hydraulicking it tends to settle to the bedrock. There is probably some gold scattered through the upper gravels and in the gravels overlying the lower boulder clay. Some gold is also said to have been found on the high "points" of rock. The gold is mostly fairly coarse, much flattened, and worn, and is similar to what is referred to in this report as glacial gravel gold.

The Slough Creek benches appear to extend only a short distance beyond the mouth of Nelson Creek. The sides of the valley below Nelson Creek, however, are so deeply drift covered that it is impossible to tell just how far the benches extend. An attempt to hydraulic a bench of Slough Creek a short distance below the mouth of Nelson Creek was made by the Cariboo Exploration Company when operations were being carried on at the Slough Creek mine. Water was brought from New Creek by a ditch 1½ miles long. One 4½-inch monitor under a head of about 300 feet was used. The bedrock was reached and proved to be fairly flat and at nearly the same level as one of the benches on the east side of Nelson Creek. Some gold was recovered, but the water supply was small and work was carried on for only one season (1899). The deposits overlying the bedrock have a thickness of 20 to 50 feet and consist mostly of glacial silt and clay. There is said to be a small thickness of gravels beneath the clay, but these are not exposed. It is possible that the rock bench extends for some distance downstream, but, judging by the steep slope of the valley side above, it does not seem probable that higher benches corresponding to those on the east side of Nelson Creek occur.

Dragon Creek

Dragon Creek flows into Willow River on the south side, and is reached by a road 4 miles long which leaves the main highway at Devils Lake Creek. The lower part for nearly three-quarters of a mile up from the mouth has a low gradient and is in the broad, deeply drift-filled valley of Willow River. Above this broad part the creek flows for 400 feet through a narrow rock canyon on the east side of which is an old buried channel of Dragon Creek.

The possibilities on Dragon Creek include drifting of the buried channel alongside the canyon; drifting on bedrock at the head of the hydraulic pit at the east side, where the bedrock channel is slightly deeper than where drifted on the east side; and extending the hydraulic pit upstream. The ground above the present head of the pit is believed from the results of drifting in the early days—about which little is definitely known—to contain sufficient gold to pay for hydraulicking, but no drilling to test the ground has been done.

Upper Lightning Creek

Lightning Creek, one of the most famous gold-bearing streams of Cariboo, rises in Bald Mountain Plateau, near the source of Jack of Clubs Creek, and flows northwest and west for 25 miles to its junction with Swift River. The two streams form the headwaters of Cottonwood River, which flows into the Fraser about 12 miles above Quesnel. The valley of upper Lightning Creek down to Stanley, 7 miles from its source, is narrow and steep-sided. The creek flows in a comparatively wide and flat-bottomed valley for 7½ miles from Stanley to Beaver Pass House, except that just below Stanley and opposite the lower part of Davis Creek the valley is partly blocked by morainic deposits of a valley glacier. The stream along this stretch has been diverted to the south side of the valley by the moraines and in a few places flows over bedrock. There are no moraines in the valley bottom below the mouth of Davis Creek and the valley flat is 500 to over 1,000 feet wide. The depth to bedrock is 100 to 200 feet or possibly more in the part below Stanley. The deep rock channel, where it has been mined, was found to be 100 to over 250 feet wide. At Beaver Pass House the main valley swings off towards the north through Beaver Pass and the present stream flows southwest in a comparatively narrow, V-shaped valley and continues in it to below Wingdam, 6 miles below Beaver Pass House and 4 miles from the junction of Lightning Creek and Swift River. It is possible that the main drainage of Lightning Creek at one time went by way of Beaver Pass and that the present drainage in the section from Beaver Pass House to Wingham has been reversed, but the depth to bedrock in Beaver Pass—which if known might determine the matter—is not known.

Overlying the bedrock in the valley bottom the deposits are mostly glacial, consisting of boulder clay, stratified sands and gravels, and silt or clay (slum), and, at the surface, alluvial deposits of the present streams.

Mining on upper Lightning Creek during the past few years has been done only by a few miners working individually; the last important work was that by L. A. Bonner in 1919.

The Last Chance hydraulic mine at the mouth of Last Chance Creek near Stanley has been operated for over twenty-five years, water under a head of about 220 feet being obtained by a ditch from Van Winkle Creek and Grub Gulch. The ground in the pit at its head was also drifted on bedrock and, probably, for some distance upstream. In the pit there are masses of large boulders above the posts of the old driftings. These boulders cause trouble in hydraulicking as they have to be blasted, but considerable gold is said to be recovered annually.

The total production of gold from Lightning Creek and its tributaries is not definitely known. It was estimated that during the first period of active mining, from 1861 to 1864, the Campbell and Whitehall claims yielded $200,000, that Van Winkle Creek produced a large amount, and that the yield from Last Chance Creek was over $250,000. As several other claims on Lightning Creek were productive, and as the tributaries Chisholm (especially the branch Oregon), Davis, and Anderson were mined, to some extent at least, as well as Van Winkle and Last Chance, it is possible that the total production during this period was at least $2,000,000. During the second period of active mining, from 1870 to 1876, the total amount yielded by the leading claims was at least $1,500,000. During this period the tributary streams and other claims on the main stream were probably also productive to some extent. From 1876 to 1895 the total production of the creek and its tributaries, as given in the Annual Reports of the Minister of Mines, B.C., was approximately $850,000, of which the tributary streams produced about $200,000. The average annual production of gold since 1895 is not definitely known, but was probably about the same as that of the previous ten years, namely, about $15,000. In 1905 and 1906 the La Fontaine mine produced $37,450 in gold; in other years the production of other properties considerably increased the average amount, but in some years it fell below $15,000. It would appear, therefore, that the total production was between $5,000,000 and $6,000,000. It is held, however, by some of the local mining men who took part in the early mining operations that the total production was between $12,000,000 and $13,000,000. They hold that the 25 per cent extra estimated in the Annual Reports of the Minister of Mines, B.C., for the unreported gold, was not large enough. But there is no way of telling just what was the actual gold production. As examples of the working expenses and profits of two of the early mines, the following records, obtained from the old books, for copies of which the writer is indebted to F. J. Tregillus, may be quoted. The mining costs at Van Winkle mine for fourteen weeks, from August 8 to November 7, 1875, amounted to $19,398.50 and the gold production $171,309.35. The South Wales Company, consisting of ten interests, paid dividends in six months from May to October, 1871, amounting to $76,385. The cost of opening the claim from May, 1870, to April, 1871, was $9,811.81. The average price obtained for the gold was $17.65 an ounce. At La Fontaine the gold averaged very nearly $18 an ounce.

GEOLOGY AND PLACER DEPOSITS OF QUESNEL FORKS AREA, CARIBOO DISTRICT, BRITISH COLUMBIA[1]

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

CONTENTS

INTRODUCTION

This report is based on field work carried out during the field seasons of 1931 and 1932. Field work was started in 1931 by W. E. Cockfield and was continued in 1932 by both authors. The description of the bedrock geology is very largely the work of the junior author, and that of the superficial deposits and placer gold deposits that of the senior author.

Efficient assistance in the field was given by N. McKechnie, H. Sargent, and H. K. Long in 1931, and by H. Sargent, V. J. Dalton, and J. C. Hall in 1932.

A reconnaissance map was made of Cariboo District in 1887 by A. Bowman (1)[2], and that map and report have to date largely furnished the knowledge of the geology of Hydraulic area. Reports on individual placer and lode properties have been made from time to time in the Annual Reports of the British Columbia Minister of Mines, and in 1922 W. A. Johnston (6) reported on the discoveries made at Cedar Creek the previous year.

Historically the area is of great interest in that its discovery antedates that of Barkerville area by several years. Placer miners in the late fifties began following the trail of fine gold up Fraser River in the belief that it would lead to rich deposits of coarse gold in the mountains near the sources of the river. In 1859 they reached the mouth of Quesnel River and, working up that river, reached the Forks in the following year. From that point the search extended up the North Fork to Cariboo Lake, and thence across the summit to the creeks of Barkerville area. The opening up of the Bullion mine as a large hydraulic property has had an undoubted influence on the history of the area. Prior to that time no really large scale operations had been undertaken. In 1921, with the dis-

[1]A preliminary edition of the geological map of this area is being prepared for publication.
[2]Numbers such as this will enable the reader to find the complete bibliographic reference in the list of papers at the end of this report.

covery of the rich ground on Cedar Creek, mining in the area again received an impetus, which has led to a very considerable amount of prospecting.

The actual gold production of the area is not known. Quesnel District, of which Hydraulic area forms a part, has produced between $5,750,000 and $6,000,000 since 1874 and a fairly large amount of gold was undoubtedly produced prior to that date. It is probable that a considerable proportion of this production came from Hydraulic area.

LOCATION AND ACCESSIBILITY

The area lies between latitudes 52° 30′ and 52° 45′ and longitudes 121° 30′ and 122°, and is situated astride Quesnel River, extending westerly from near the lower end of Quesnel Lake to a short distance below the mouth of Birrell (Twentymile) Creek. The northern boundary of the area passes about 6 miles north of Quesnel River and its tributary, North Fork of Quesnel River, and the eastern boundary crosses Cedar Creek, and the North Fork of Quesnel near the mouth of Spanish Creek. The area is of considerable interest as a placer mining district in that it includes such well-known properties as the Bullion, Cedar Creek, Morehead, and others.

Most parts of the area are readily accessible. An automobile road, extending from the main Cariboo highway at Mountain House to Keithley Creek, passes through the central part of the area. The distance by road from Williams Lake, a town on the Pacific Great Eastern Railway, to Beaver Lake, near the southern boundary of the area, is 40 miles. A second road, which is, however, passable only in dry weather, passes along Quesnel River from the town of Quesnel and joins the Keithley road at Hydraulic. In addition there are several branch roads; one of these extends down Beaver Valley 4 or 5 miles below Beaver Lake; a second runs from the Keithley road to Polley Lake and to the western side of Quesnel Lake; a third extends a short distance down the north side of the North Fork of Quesnel River from the mouth of Spanish Creek, and others lead to Spanish Lake, Cedar Creek, and to Quesnel Forks.

A trail from the North Fork of Quesnel River, opposite the village of Quesnel Forks, leads up Maud (Fourmile) Creek to the northwestern boundary of the area and beyond. This trail joins a road, now abandoned, which passes up Birrell Creek from Quesnel River towards Swift River. Another trail runs from the end of the Polley Lake road toward Horsefly, passing through the southeastern part of the area; and there are also trails from the main road to Jacobie (Eightmile) Lake and Bootjack Lake, and trails along parts of North Fork, South Fork, and Quesnel Rivers. Another trail extends from the North Fork to Duck Lake. There are, consequently, few parts of the area very remote from either a road or a trail.

Quesnel River may be crossed by means of a cable carrier at the mouth of Birrell Creek, and the North Fork may be crossed by means of a private cable ferry at Quesnel Forks, and by the highway bridge at Spanish Creek. The South Fork has two bridges, one at Quesnel Forks and the other at Likely.

A map of the area on a scale of 1 inch to 1 mile is being prepared from aerial photographs, but the ground control surveys have not been completed. The aerial photographs were, however, available for use during the course of geological work and were used in part to record geological observations. With the aid of a stereoscope the ground could be examined in advance of the actual traversing. On account of the heavy growth of timber, outcrops of rock could rarely be recognized from an examination of the photographs, but areas where outcrops were likely to occur could frequently be located and other areas eliminated. Points where good sections of the unconsolidated deposits were obtained could almost invariably be spotted on the photographs.

TOPOGRAPHY

The area is relatively low and with somewhat subdued relief. The main streams occupy deep and somewhat narrow trenches, but if these be eliminated it will be found that most of the area lies at or above an elevation of 3,000 feet above sea-level. The highest point is Kangaroo Mountain (4,767 feet) and the lowest point attained by Quesnel River within the area is slightly under 2,000 feet. The maximum relief is thus roughly, 2,800 feet. Few of the hills, however, rise much above 4,000 feet, so that the general aspect of the region is that of a gently rolling country with somewhat rounded hills rising from 500 to 1,700 feet above the general level.

To the north and east, beyond the borders of the map-area, the hills rise much higher. Cariboo Mountains lie to the east and northeast. The area thus occupies a part of the plateau region of British Columbia, which is bounded on the west by the Coast Range and by Cariboo and other ranges on the east.

The valley bottoms range from about 2,000 to 3,000 feet above sea-level. The larger and more important valleys are deeply-cut, relatively narrow trenches in the upland surface. The major valleys consist of the Quesnel and its main tributaries, the North Fork and the South Fork, and Beaver Creek. This latter stream does not join Quesnel River within the limits of the map-area. The smaller streams nearly all enter the major valleys through canyons cut either in bedrock or in unconsolidated deposits.

The drainage pattern of the area shows a northwest-southeast direction, but there is a subsidiary direction at right angles to this. Quesnel River flows in a general westerly direction within the limits of the map-area, but has, on the whole, a northwesterly trend.

Most of the area is rather heavily timbered and the growth of underbrush is in most places sufficient to make traversing somewhat laborious.

GENERAL GEOLOGY

Bedrock Geology

The bedrock geology of the quadrangle was first examined by Amos Bowman (1) who made a report on an extensive geographical and geological reconnaissance survey of Cariboo Mining District during the years 1885 and 1886, accompanied by a geological map.

The northwesterly trend of the formations is clearly shown on his map and discussed in the text of the report. The rock formations southwest of Beaver Valley are mapped as Upper Palæozoic, Bear Lake beds probably in part of Carboniferous age and equivalent to the Cache Creek series of earlier reports. The formations from Beaver Valley to the North Fork of Quesnel River near Kangaroo Creek are mapped as Quesnel River beds (Lower Cretaceous in part) consisting of volcanics and sediments. Northeast of the Quesnel River beds a belt of Archæan (?) Quesnel Lake crystalline rocks is shown lying across the unmapped part of the Hydraulic quadrangle. Tertiary lavas are shown close to Beaver Valley.

Detailed work within the quadrangle has not materially changed Bowman's conception of the broader geological features.

The extensive mantle of unconsolidated materials throughout the area, and particularly along a wide belt bordering Beaver Valley on the northeast, has so masked the bedrock that relationships between the different lithologic formations can seldom be found. Field and laboratory work to date allow a tentative grouping of the rock formations given in the following pages, which must be considered as a preliminary report and by no means final.

Conglomerate and Arkosic Sandstone

Fairly extensive exposures of conglomerate and sandstone occur on the southwest side of Beaver Valley west of Opheim Lake and again along the bed of a small creek flowing into Beaver Creek close to the highway just south of the map-area. The formation strikes along the direction of the valley and dips from 45 degrees to 70 degrees to the southwest, the steeper dips being found up the hill to the southwest. The conglomerate beds, which are found up the hillside, grade from a cobble to a pebble conglomerate and through arkosic grits to arkosic sandstone with some shaly beds. The cobbles and pebbles are chiefly quartzite with some of argillite. The colour of the formation varies from brownish red to grey. A specimen from a grey arkosic grit examined under the microscope was found to consist of angular grains of quartz and some sericitized feldspar loosely bound together in a matrix of chloritic material. These rocks, though quite fresh in appearance, are highly tilted and the massive members slightly sheared or jointed. The coarser beds were found up the hillside or up in the section as now exposed.

Two isolated outcrops were found in the beds of two small streams flowing into Chambers Lake from the west, near the middle and north end of the lake. Here the strata strike nearly east and west, with low south dips, toward argillite and undifferentiated greenstone and unless they pass beneath these formations the relationsihp must be a faulted one.

Immediately north of Joan Lake, on the west side of Beaver Valley, are outcrops of dark grey, fine-grained conglomerate, composed of rounded and partly rounded particles of quartzite and cherty argillite, which appear to grade into a greenish volcanic conglomerate somewhat coarser in grain. At other points along this hillside are dark grey, gritty beds between either flows or sills of dark grey andesite, which strike east and west and dip at a low angle to the south.

Cobble conglomerate outcrops in Maud Creek gorge in the vicinity of the first fork and along the north side of Quesnel River Valley between Maud Creek and the South Fork. Finer conglomerate and arkosic grit outcrop on the second fork of Maud Creek and between the first and second forks $\frac{3}{4}$ mile east of the main creek. Highly carbonaceous beds outcrop in the bed of the first fork of Maud Creek within the area of conglomerate outcrops and appear to be interbeds, strike east and west, and dip to the south. The conglomerate is either overlain or intruded by greenstone on the west side of Maud Creek, for the latter forms high bluffs on that side of the creek above the conglomerate.

Actual relationships between the conglomerates and sandstones with other formations have not been observed. On the southwest side of Beaver Valley the formation appears to dip under limestones and cherty argillites, referred by Bowman to the Cache Creek series, and to strike and dip either into or under argillites intruded by greenstones and to be intruded or interbedded with andesitic rocks. No fragments of either volcanic material or limestones were found in the coarse phases, which lends strength to the belief that the formation passes under the limestone and the volcanic formations. Evidence to the contrary is found in an increase in size of grain upward in the section and the apparent faulted relationship in the two creek exposures previously noted. This suggests that the formation may be overturned and, or, faulted against the formations bordering it to the southwest. The writer inclines to accept the first hypothesis as the more probable one.

Limestone, Cherty Argillite, and Greenstone

In the southwest corner of the map-area the summits bordering Beaver Valley are composed of limestone, cherty argillite, and greenstone. The limestone, which forms the greater part of the exposures, is grey in colour, finely crystalline, fractured and filled with calcite veinlets, and structureless. The ridges and outcrops trend, however, in a northwesterly direction. The cherty argillites, dark grey in colour, are intruded by light greenish grey greenstone and occur in isolated outcrops. About $3\frac{1}{2}$ miles due west of the south end of Opheim Lake is an outcrop of grey-white, red-brown weathering, siliceous limestone, partly altered to ankeritic carbonates and containing a little mariposite. This outcrop suggests the alteration of limestone close to an igneous contact and this belief is supported by the presence immediately to the east of a crumpled and altered cherty rock suggestive of being a silicified argillite. A mile northwest, along the trend of the formation, is an outcrop of dense, cherty, greenish grey greenstone weathering to a brownish colour and displaying on the weathered surface its fragmental origin, probably a tuff. Northeast of this outcrop, $1\frac{1}{2}$ to 2 miles due west of Chambers Lake, are a number of outcrops of siliceous argillite and what appears to be a greenish grey tuff and greenstone of unknown origin. The sediments strike east and west and dip 55 degrees south to vertical.

These outcrops have tentatively been mapped under one colour and correspond to the rocks referred by Bowman (1) to the Cache Creek series. The writer is inclined to believe that these rocks overlie the conglomerate-sandstone formation and may ultimately be correlated with Jurassic (?) sediments previously mapped with the volcanic series to be described on a later page.

Greenish Grey Volcanics

Grouped under this heading are a variety of extrusives and intrusives, chiefly augite andesite porphyry and volcanic breccia, with some sediments that probably belong to the afore-mentioned sedimentary formations.

Typical exposures of these rocks are to be found on the summits of Maud, Texas, and Kangaroo Mountains north of Quesnel River Valley, as well as in the vicinity of Joan Lake in Beaver Valley.

The rocks of this assemblage are commonly dark grey to greenish grey in colour, fine grained and porphyritic. The groundmass varies from finely granular to dense and even cherty in appearance and the phenocrysts are generally well-defined, small crystals of olive green to dark green pyroxene. Breccias are fairly common and occasionally beds of fine-grained, grey tuff occur. The prevalent porphyritic varieties examined under the microscope show the groundmass to be composed of plagioclase feldspar, chlorite, and sometimes glass, and the phenocrysts to be, generally, well-defined crystals of augite and, occasionally, ill-defined plagioclase feldspar. In a few cases hornblende takes the place of augite. The rocks average about augite andesite porphyry.

In the vicinity of Lowdon signals, a little over a mile west of Kangaroo Creek, members of this group intrude light-coloured, cherty beds which look like silicified tuffs. On the south side of Quesnel River 1 mile below the South Fork, cherty argillites are also intruded by members of this group. Northwest of Joan Lake, in Beaver Valley, members of this group are interbedded with, or intrude, fine conglomerates and grits believed to be part of the conglomerate-sandstone formation. Other exposures of this group are found in the vicinity of Joan Lake and again in the southern part of the area east of the highway.

Purplish Brown Volcanics

Extending northwesterly across the central part of the map-area, between the exposures of greenish grey volcanics, is a wide belt of volcanic rocks characterized by a purplish to red-brown colour. These volcanics present a wide variety in appearance and character from massive flows to coarse breccias. A fresh-looking flow rock—purplish brown on fresh fracture with dark green pyroxene phenocrysts—weathers to a violet-brown colour, the phenocrysts weathering more easily than the groundmass, giving the rock a pitted appearance. Under the microscope this rock is seen to be composed of a groundmass of fine laths of plagioclase feldspar, strained glass (?), and red iron oxide with indistinct phenocrysts of plagioclase feldspar and abundant ones of sharply defined, fresh, pale green augite. Another distinctive member of this assemblage, found at intervals from the summit east of Polley Lake to the north side of Quesnel River east of Birrell Creek, has a finely granular, purplish brown groundmass with somewhat rounded phenocrysts of salmon-coloured feldspar and a few of olivine. This rock weathers to a darker colour and the phenocrysts show up white on the weathered surface. A phase of this rock has a greenish grey groundmass. This volcanic assemblage is characterized by an abundance of breccias which grade from what are probably ash rocks to quite coarse, angular breccias containing foreign volcanic fragments. The coarse phase may be a very coarse explosive breccia or a detrital deposit. The common phase is an ordinary breccia of medium grain composed of angular fragments of the same material up to a few inches in size.

Within this volcanic assemblage is a well-defined band of grey limestone, weathering brownish to grey-white, striking across the highway a mile southwest of Morehead Lake. It is again exposed on the summit west of the little creek between Morehead and Buxton Creeks and on the north side of Quesnel River in the gorge of a small creek 2 miles east of Birrell Creek, and lastly on the hillside half a mile to a mile west. In the latter exposures the limestone grades into a purplish, impure limestone containing either fine detrital material from the volcanics or ash of the same character.

The hydraulic pit on Morehead Creek, about a mile from the creek mouth, has exposed fossiliferous argillites in close proximity to purplish volcanics, but without actually revealing their relationship. The argillites are well banded and folded, with a general strike north of west and southerly dip. The argillites grade into fine, gritty beds which strongly resemble the dark grey, gritty beds associated with the greenish grey volcanics northwest of Joan Lake. A collection of fossils was made in 1931 and submitted to F. H. McLearn, Geological Survey, who reports as follows:

"Lots E and F from Morehead (Sevenmile) Creek, Fraser River district, contain ammonites, belemnites, pelecypods, etc., which belong to a new or little known fauna. An extended investigation should be made of these collections before any exact identification or correlation can be made. The ammonites appear to be of Jurassic age and I would advise Mr. Cockfield to map the strata containing them Jurassic, at least tentatively."

Greenish grey volcanics outcrop within 20 feet of the argillites and the relationship appears to be an intrusive one. Similar rocks cut the purplish volcanics a short distance from the argillites up the pit. The similarity between the members of this argillite exposure and other exposures of argillite within the map-area leads the writer to believe that they are probably older than the volcanic rocks.

Rocks of the purplish volcanic assemblage appear to be interbedded with those of the greenish grey assemblage at a few places close to the boundaries of these assemblages. Apart from the coloration of the groups the rocks are quite similar in mineralogical composition and it is only the presence of the red-brown iron oxides and prevalence of breccias that differentiate the one group from the other. The writer believes from all the evidence available that the whole represents a more or less continuous volcanic succession accompanied by one short interval of sedimentation.

A number of outcrops have been mapped as undifferentiated volcanics and sediments. It is evident from the position that some of these outcrops bear to others mapped as one or other of the volcanic assemblages that they undoubtedly belong there. In the canyon of Maud Creek, above the second fork, argillites, limy argillites, sandy argillites, and graphitic argillites are badly contorted, intruded by greenstone, and apparently overlain by it. These sediments, as well as others mapped as undifferentiated, probably belong to the older sedimentary rocks and have been mapped with the volcanics because they are generally intruded by them or in such close proximity and of such small area as to make distinction in mapping difficult.

Igneous Rocks

INTRUSIVES

Igneous rocks, some of which are known to be intrusive, and others that are believed to be, outcrop in a number of small, scattered exposures. They vary from syenite to monzonite and pyroxenite.

Syenite

Medium to fine-grained, light grey augite syenite outcrops on Bootjack Mountain. A syenite porphyry, with flesh-coloured phenocrysts of feldspar in a dense, flesh-coloured groundmass in which small amphibole laths are visible, outcrops on a small knoll about 1 mile east of the highway and $1\frac{1}{4}$ miles north of Jacobie (Eightmile) Lake. On the weathered surface the phenocrysts show white against a light brownish coloured groundmass. Between this outcrop and Jacobie Lake there is another one on a knoll, of a weathered grey, syenitic-looking rock with fawn-coloured phenocrysts of feldspar.

A syenitic-looking rock rich in salmon-coloured feldspar, which gives it a flesh-coloured appearance, outcrops on Polley Mountain and on the ridge running northerly from it. A similar rock but of fine grain outcrops on the Polley Lake road 2 miles from the highway. A flesh-coloured syenite cuts medium-grained, dioritic-looking rock in the Bullion pit.

Granite to Granodiorite

A medium to fine-grained rock in which white feldspar and quartz are visible outcrops northwest of Joan Lake on the summit of the ridge. Inclusions of dark material were observed in this rock and it quite apparently cuts the volcanics.

A medium to fine-grained, grey rock, with visible white feldspar, biotite, amphibole, and epidote, containing altered inclusions of dark material, outcrops on the north side of Quesnel River opposite Buxton Creek. A mile to the northeast on Birrell Creek white granite and grey granodiorite are intrusive into what appears to be an altered tuff. Grey, granitic rock, identical with the large exposure opposite Buxton Creek, outcrops on the road at the crossing of Buxton Creek and for nearly a mile upcreek shows intrusive relationship to volcanic rocks. This rock outcrops again on the knoll between Buxton Creek and Quesnel River. These outcrops appear to form part of a continuous mass of granodiorite.

Monzonite

A fine, granular, light grey rock with indistinct phenocrysts of feldspar outcrops on the north side of Quesnel River 2 miles west of Maud Creek. It is cut by a dyke of dense, grey rock in which biotite and some feldspar are visible. The nature of this dyke has not been determined.

Pyroxenite

A pyroxenite of medium grain intrudes cherts on the low summit north of Quesnel River a mile west of Kangaroo Creek.

A gneissic, grey, granitic rock outcrops at the outlet of Trio Lake and may be a phase of the Bootjack Mountain syenite, but appears to more closely resemble a diorite.

A few outcrops of granitic rock occur at other places in the area and have not been specifically determined.

Tertiary

Olivine basalt has been found at several places along the northeast side of Beaver Valley and on the north side of Quesnel River west of Birrell Creek. It occurs in flat-lying flows of dense, columnar, and vesicular basalt. The surfaces of some flows are smooth, whereas others are rough and approach ropy structure. The best exposures are along Beaver Valley north of Jacobie Creek where the basalt forms cliffs up to 150 feet in height.

Under the microscope the rock is found to be exceedingly fresh with phenocrysts of olivine in a groundmass of plagioclase, feldspar, olivine, and pyroxene.

The basalt has been found low down in Beaver Valley bottom, as well as along the rim of the valley and in one place on the low summit west of Birrell Creek. Although it is possible that the basalt has extended back on to the low summits bordering Beaver and Quesnel Valleys the remnants left are essentially of a valley-fill occurrence.

Reinecke (9) described similar lavas from the " Chasm " near 59 Mile House and at other points northerly to Quesnel, and found them resting on beds of the Fraser River formation which he assigned to the late Miocene. More recent work by the senior author (2) has shown the Fraser River beds to be late Eocene in age, hence the basalts of Reinecke are definitely post-Eocene. Similar basalts have been described by the writer (12) in Clearwater River Valley and shown to be younger than Tertiary lavas described by Uglow (11) as Skull Hill, which rest upon the tilted and eroded edges of early Eocene sediments in North Thompson Valley. Allowing for a period of tilting and erosion of the Eocene sediments as described by Uglow (11) and for the outpouring of the intervening Skull Hill lavas it is a reasonable assumption to follow Reinecke (9) and place the olivine basalts in the Miocene or perhaps even in the Pliocene. The removal, however, of great masses of these lavas in pre-Glacial time tends to suggest a Miocene age for them.

Structure

Bowman (1) postulated a synclinal structure striking northwesterly across Hydraulic area and detailed work, although not definitely confirming this structure, at least lends support to his hypothesis. No repetition of the limestone member of the purplish volcanic assemblage has been found, but this member does not appear to be continuous along the strike, rather occurring as thin, lenticular beds which may not appear at the surface again through folding.

The manner in which the purplish volcanics narrow northwesterly suggests an anticlinal or synclinal structure and such dips as could be obtained tend to suggest the latter structure. The lack of volcanic fragments in the conglomerate formation and the intrusive relationship of members of the volcanic assemblage into sedimentary rocks lends support to the belief that the volcanics are younger than the sedimentary formations, and further that an unconformity probably exists at the base of the volcanic assemblage. The proximity of the fossiliferous argillites to purplish volcanics in Morehead hydraulic pit suggests that if the argillites are older than the volcanics, unconformities exist within the volcanic assemblage, or that this assemblage was laid down upon an irregular floor, the lower parts of which were filled during the first stages of vulcanism, leaving the higher parts exposed to be covered by the later volcanics.

Description of Rock Formations in the Unmapped Part of the Map-area

The following brief description of the rock formations in the unmapped, northeastern part of the map-area treats them in the order in which they occur from southwest to northeast across the trend of the formations.

Purplish brown and greenish grey volcanics outcrop along the west side of Quesnel Lake in the extreme southwest corner of the map-area and again south of the road from Hydraulic to Likely, between the Polley Lake road and Quesnel Lake. These outcrops line up with those described on the map, the greenish grey volcanics lying northeast of the purplish brown type.

Argillites with conglomerate interbeds outcrop on the west side of Quesnel Lake a short distance above Poquette Creek and again between Likely and Poquette Creek where they are associated with greenish grey volcanics and limestone. The limestone here is in narrow bands, but may well be the same horizon as that exposed in the extreme southwest corner of the map-area providing the synclinal structure postulated exists across the area. The conglomerate beds at the outlet of Quesnel Lake have a matrix of volcanic material. At Rose Gulch on the north side of the South Fork of Quesnel River conglomerate beds are of purely sedimentary material.

Greenish grey volcanics, consisting of flows and fragmentals, outcrop on Cedar Creek and are cut off to the north and northwest by granodiorite which lies east of Quesnel Lake toward Poquette Creek. Similar volcanics again outcrop east of Poquette Lake.

On the north side of the North Fork of Quesnel River, in the gorge of a small creek east of Kangaroo Creek, greenish grey volcanics are intrusive into, or interbedded with, carbonaceous argillites. Carbonaceous argillites intruded by greenstone outcrop on the North Fork of Quesnel River below Wolverine Creek. Above Wolverine Creek to Spanish Creek the argillites are highly sheared and pass into carbonaceous and graphitic schists.

The summit north of the North Fork of Quesnel River between Kangaroo and Wolverine Creeks is almost devoid of outcrops.

Between Wolverine and Duck Creeks and the North Fork of Quesnel River is an area in which crystalline, sericitic and chloritic schists, and sheared, porphyritic granite form the chief outcrops. The sheared, porphyritic granite lies west of the North Fork of Quesnel River above the bend where Spanish Creek joins the river. The relationship of these crystalline schists to the carbonaceous schists and argillites to the south west is not known, but they appear to have suffered greater metamorphism and, as Bowman has described them, appear to belong to an older formation.

UNCONSOLIDATED DEPOSITS

The unconsolidated deposits overlying bedrock belong mainly to the Pleistocene and Recent, that is deposits formed during the Ice age and deposits formed since the retreat of the ice from the district. They include not only those deposits formed during periods of the temporary retreat of the ice from the region, known as interglacial deposits, but probably also include gold-bearing gravels that may be preglacial.

The Recent (post-glacial) deposits have been formed mainly by streams eroding the glacial deposits and also, to a limited extent, the bedrock. These consist of sands, gravels, clay, silt, and peaty material deposited mainly in the valley bottoms of the present streams; but they occur also on the benches bordering the present streams. These deposits are usually thin. In one case a deposit of marl, with shells believed to be existing forms, was found on a bench overlying glacial gravels.

The glacial deposits are abundant in the area, covering most of the upland surface and filling the valley bottoms to a considerable depth. The glacial drift consists of boulder clay, of stratified deposits of sand and silt, locally known as "slum," and of stratified deposits of gravel, sand, and clay. The boulder clay varies considerably in appearance, being in places very stony and in others remarkably free from stones. In some sections there are considerable thicknesses of unstratified clay almost free from boulders, and in other sections boulders appear in intermittent fashion, that is the section consists of clay with widely separated boulders. Somewhat similar deposits of stratified clay were noted and in these cases the strata appeared to be deflected downwards below the pebbles and boulders, as though the pebbles had been dropped into the soft material, presumably from floating ice. It would appear that the more clayey part of the boulder clay in some instances was deposited in water, possibly as the ice melted. A noteworthy feature with regard to the boulder clay is the amount of water-worn gravel or boulders included in the deposit. These range all the way from irregular masses of gravel included in the boulder clay to isolated pebbles or boulders in a considerable thickness of clay. In some instances nearly all the pebbles or boulders consist of typical stream wash, deposited in irregular fashion in unstratified clay. The inference is that the glaciers accomplished very considerable erosion on pre-existing gravel deposits and scattered the materials so derived over a wide area.

The thickness of the boulder clay varies considerably from place to place, or even in a single section. Few sections were noted in which a single deposit of boulder clay exceeded 100 feet in thickness; in others, however, the thickness is only 10 to 15 feet. It appears probable that the thickest sections are to be found in the valleys, but it must be admitted that in most cases the thickness of the drift on the upland surface is not known. Over large parts of the area the glacial drift is sufficiently thick to render rock outcrops exceedingly scarce.

The glacial outwash deposits are those deposited by streams, and possibly also in lakes fed by glacial streams, coming from the melting ice. These outwash deposits are very well developed in the area, forming huge banks of gravel, sand, clay, and silt. The deposits are usually stratified, the strata being marked by the sorting of the materials into alternate layers of fairly coarse and fairly fine gravels, in many cases with the inclusion of layers of sand or clay. The strata are inclined in many of the sections, and lensing, crossbedding, and rapid changes in the character of the deposits from point to point in a single section may be cited as reasons for believing that they were deposited by heavily overloaded streams. The dips of the strata noted were in some instances quite high. At Quesnel Forks, on the south side of the South Fork of Quesnel River, the strata of the outwash gravels have a dip of from 30 to 35 degrees into the hillside, that is away from the present stream. On the opposite side of the valley, north of the main Quesnel River, the strata dip in the opposite direction. On Birrell Creek, a tributary to Quesnel River, a large section of outwash gravels is exposed showing a dip of 10 to 15 degrees towards the south, that is, towards Quesnel River; although the apparent dips may in some instances be due to slumping, it is considered probable that in others they were deposited in the position in which they now occur.

The stratified combination of silt and clay, or of sand and silt, forms a considerable part of the valley filling, and occurs at various elevations above the valley floors. The glacial gravels contain considerable quantities of it. It varies in composition from clay to a mixture of sand and silt. The silt quite generally shows a regular banding due to an alternation of fine and coarse material; the stratification in many instances is so uniform as to lead to the supposition that it was deposited in a series of lakes. In places, however, crossbedding was noted in such deposits. In the pit of the Matthias Gold Mining Company on the north side of the North Fork of Quesnel River definite crossbedding was noted in the stratified silts. The stratified silt and sand, or silt and clay, is in most cases quite readily permeable by water and when in such condition flows readily. Such deposits are usually referred to by the miners as "slum." Instances were noted, however, where the silty clays had hardened or been cemented to the extent that they would give a ringing sound when struck with the hammer. In one or two places fragments of logs buried in the silt were noted. These log fragments were reduced to the condition of punk, indicating that the deposition was Recent.

The prevalence of clay and slum in the drift deposits has resulted in a number of slides along Quesnel River. Places were noted where slides involving banks of unconsolidated materials of considerable heights had occurred, probably temporarily damming the river, with the river cutting through the dam and forming a bar immediately below. In other instances where the river approaches a bank of such material great cracks extending to the surface for some distance back from the stream give evidence of gradual movement of the mass towards the river.

There is some evidence that the outwash deposits were deposited at an early stage in the glacial history of the region, probably before the actual arrival of the ice in the district. On Birrell Creek a generalized section shows stratified sands and silts overlain by stratified gravels and sands. The latter apparently have been eroded with boulder clay deposited against the eroded edges. Although the relations are somewhat obscured by sloughing of the material in the banks, it is evident that the strata of the gravels, if produced, would pass out into the boulder clay. Somewhat similar relations were noted at several other points in the district; at the Hepburn pit on the North Fork of Quesnel River, and at the pit of the Quesnel Gold Mining Company directly opposite the Hepburn pit. The occurrence of boulder clay resting on top of the stratified outwash deposits is not an isolated phenomenon, but may be observed at many points in the area.

Stratified silts were noted at elevations up to 600 feet above the valley bottoms. It is usual to find them at the higher elevations as remnants of more or less well-marked terraces, a fact that shows they were once more extensive than at the present time. Even at these levels the silts are in some sections overlain by boulder clay. The facts, therefore, point to a deposition of some of these deposits in an early stage of glaciation and their subsequent erosion either during a period of retreat of the glaciers or by a re-advance of the ice. It seems probable that they owe their origin to valley glaciers existing higher up in the valleys, from which it would follow that the initial glaciation was probably of the valley type. The outwash deposits form a very considerable part of the glacial drift of the area. Sections of drift 300 to 400 feet high must lead to the conclusion that large volumes of water were available and that the removal of material from other parts of the region must have been rapid.

Interglacial Deposits

Deposits formed during more or less temporary periods of retreat of the ice from the area were found at several points. Thus at the Bullion mine there are two boulder clays with a considerable thickness of stratified sands and gravel separating them. Attention was drawn by Dawson (3, 1894, page 24A) to the boulder clays existing at this point; the lower boulder clay resting on stratified gravels and containing only a minimum of boulders, followed by stratified gravels, sand, and silt, overlain in turn by a stony boulder clay. Dawson concluded that the lower gravels were probably preglacial and the gravels lying between the two deposits of boulder clay were interglacial in age. In raising from the sluice tunnel (*See* description of Bullion mine) a fossil skull, *Oreamus montanus,* was encountered which would probably place these lower gravels as Pleistocene. Of this, C. M. Sternberg says "The portion of fossil cranium is a Rocky Mountain goat, erroneously named since it is really an antelope (*Oreamus montanus*) belonging to the chamois group of the true antelope family (Antilopidae). This genus was evidently a late immigrant from the Old World, arriving on this continent during Pleistocene times." There is, consequently, some evidence that these gravels may themselves be considered as interglacial and that there were several periods of retreat of the ice from the region.

On Rose Gulch evidence that two deposits of boulder clay exist was obtained from the workings, and in other parts of the district there is also evidence for the existence of two such deposits. It is, however, rare to find two deposits in a continuous section and as boulder clay, by the nature of its deposition, may be deposited by a single glacier at different altitudes, such evidence must be accepted with caution.

It is obvious that there can be no sharp distinction in character between the glaciofluvial deposits, interglacial deposits, and the deposits of recent streams. In the latter two cases the material supplied to the streams is derived very largely from the erosion of glacial and glaciofluvial deposits and is, therefore, nearly identical in all three cases, but in the case of interglacial and Recent deposits there should be perhaps a more complete sorting of the material with the removal of a larger percentage of the finer material.

A study of the glacial history of the region leads to the conclusion that the history was long and complex. Evidence has already been cited to show that the initial stages were probably represented by valley glaciation; but there is also considerable evidence to show that during the Pleistocene one or more ice-sheets covered all, or most, of the area. Glacial erratics occur at all elevations on the upland except on a few of the highest ridges. Several of these ridges formed barriers across the general direction of ice movement and the occurrence of erratics at high elevations on their sides away from the source of the ice suggests that the glaciers actually crossed these summits. Boulder clay is also prevalent over much of the upland surface, but comparatively little data could be obtained as to its thickness. Considerable attention was paid to the direction of ice movements as indicated by the direction of transport of erratics. Unfortunately little is known of the minute details of the geology of the surrounding districts and such detailed knowledge is required to accurately place the origin of the float. Furthermore, owing to the scarcity of outcrops in many parts of the area itself it is felt that only a general, rather than a detailed, knowledge of the bedrock geology was obtained. In general, however, it would appear that the movement of the ice-sheet was from the northeast towards the southwest; in other words the ice moved outwards from the higher mountains lying to the northeast. In the northeastern part of the area, to the north of the North Fork of Quesnel River, there is an area of a sheared, porphyritic, granitic rock. Erratics have spread out for a considerable distance southwest of the known area of outcrop. This direction of movement applies, of course, only to the ice-sheets or glaciation of the continental type. In the vicinity of Beaver Valley a northwesterly direction for the ice is indicated, but on account of poor exposures in this vicinity the evidence is uncertain.

The valley glaciers naturally moved outward from the mountains along the main valleys and had, consequently, a movement in the area from southeast towards the northwest. Glacial striæ are quite uncommon; those noted were seen in the higher valleys and indicated a movement towards the northwest folowing the trend of the valleys in which they occurred. At one point on the upland, namely on Little Mountain, glacial striæ and chatter marks indicated an ice movement towards the northwest.

The total erosion accomplished by the glaciers must have been very great. The great volume of glacial drift in valleys such as the Quesnel, Beaver, and others, where sections of 300 to 400 feet of drift deposits are quite common, leads to the assumption that the erosion accomplished by these glaciers was great. A considerable part of the material, however, may have been brought in from points outside the area. Glacial boulders recognized as foreign to the area are quite common and it may be assumed that much of the finer material was also brought into the area. Reference has already been made to the enormous volumes of flood water probably available and also to the fact that in certain instances, at least, the materials first deposited consisted of the finer materials such as clay and sand, followed later by gravels and boulder clay. The initial stages of the glacial period were probably marked by an increase in precipitation which effected the removal of considerable quantities of residual soil accumulated after a long period of weathering in the Tertiary. As the glaciers advanced the overloaded streams built up broad flood-plains in the valleys, thus partly filling the valleys with glacial drift which was eroded by the advance of the glaciers to some extent and possibly eroded by stream action during subsequent advances and retreats of the ice. It seems probable, however, that bedrock was to some extent protected from glacial erosion by the pre-existing outwash deposits, a feature that may have considerable bearing on the possibility of preservation of any preglacial auriferous deposits that may have existed.

With regard to the upland surface there are also some reasons for supposing that a considerable amount of erosion took place. The thickness of the drift in most places on the upland is not known, but on account of the lack of rock outcrops over considerable areas it is reasonable to presume that the drift cover is fairly thick except on the higher ridges. Furthermore, the plucking away and transportation of huge erratics weighing many tons must be regarded as evidence of considerable erosive power. For example, on the lower part of Kangaroo Creek huge erratics of sheared, porphyritic granite measuring nearly 20 feet in diameter were noted, which are believed to come from the area of this rock mentioned above, and which have been transported several miles from the nearest known area of outcrop and brought to their present position by stream erosion of the glacial drift. Other large erratics occur in different parts of the area, some occurring in the valleys and some on the upland surface. Many of these have been derived from the bedrock of the area; but others have undoubtedly been transported considerable distances, being, so far as known, foreign to the rocks of the area. There is thus considerable evidence of the transportation of material from points not only within the area, but also outside of it, all of which may be cited as evidence of considerable movement on the part of the ice-sheet. On the other hand, the occurrence in places of deeply weathered bedrock, and also what are believed to be residual soils lying beneath unweathered boulder clay, implies a considerable degree of unevenness in the glacial scouring. Weathered rock surfaces lying beneath boulder clay or other glacial materials are fairly common and on Forks Creek, a small tributary to Birrell Creek, an area of deeply weathered volcanics with partly weathered blocks of the same material in a matrix of clay and overlain by boulder clay was observed. A somewhat similar phenomenon was observed on Cedar Creek near the head of the canyon. Both these occurrences lie fairly well up on the valley walls of rather narrow valleys and were consequently protected to some extent from glacial erosion. On the whole the writer believes that there is sufficient evidence for the belief that the ice-sheet accomplished considerable erosion and transportation of material. Although this conclusion may appear to disagree with Johnston's (7, 1926, page 41) conclusion with regard to the glaciation of the upland surface in Barkerville area, where a nearly stagnant ice-sheet is postulated, it should be remembered that the upland surface of Quesnel Forks area lies nearly 3,000 feet lower than that of Barkerville area and that conditions were thus essentially different.

Although the evidence obtained is on the whole insufficient to effect a complete separation of the glacial deposits formed by valley glaciation and those of the ice-sheet, it may be stated that during the Pleistocene valley glaciers were active at one or more periods and it also seems certain that one or more ice-sheets covered the entire area. Fossils obtained from the various hydraulic pits and presumably washed out of Pleistocene deposits include a fragment of a tooth of *Elephas primigenius* from the Morehead pit, left humerus of a bison, probably *Bison bison,* from the Bullion pit, and a fragment of a tooth of *Elephas columbi* Falconer from the pit of the Matthias Gold Mining Company. The occurrence of most of these forms indicates a Pleistocene age for the deposits. Mr. Sternberg, discussing the occurrence of the bison, states that it is not earlier than late Pleistocene and is more likely Recent. There is, as pointed out elsewhere, no definite evidence to show from what points in the sections concerned fossils found on bedrock in the course of placer mining have come.

ORIGIN OF THE PHYSICAL FEATURES

There are within the area considerable stretches of nearly flat upland surface at or near an elevation of 3,000 feet above sea-level. A number of rounded hills or ridges rise from 500, to a maximum of 1,700, feet above the general level. To the north and east of the area the hills are higher, but still rounded and relatively flat-topped, apparently rising gradually in elevation until the peaks of Cariboo Range are reached. It is evident that this is an old erosion surface which at one time had the aspect of a gently rolling country or plain-like surface with hills rising from a few hundred to less than 2,000 feet above the general level. The streams apparently flowed across this surface in valleys at no great depth below the general level. It appears probable that a general slope was established from the mountainous belt towards Fraser Valley. This rolling country has been uplifted and dissected in places to depths of approximately 1,000 feet.

The present major valleys are narrow, deep, and steep-walled. An examination of these valleys, however, shows very broad, shallow depressions in which the deep trenches have been cut, leading to the belief that these broad depressions mark the valleys at the time the plain-like surface was established. An uplift of the region caused rejuvenation of the streams and led to the cutting of the present narrow, deep valleys. The date of this uplift is uncertain, but some inconclusive evidence was obtained on this point. In the western part of the area are flat-lying basalts very similar to those occurring in Fraser Valley near Quesnel which Reinecke (9, page 7) classed as late Miocene. These lavas, it is believed, can be correlated with the lavas of Fraser Valley for they do not appear in the eastern part of the map-area. At several points they were found well down in Beaver Valley; in one of these cases it could not be definitely established whether the occurrences were actual outcrops or huge blocks of talus which had descended into the valley, in the other cases the occurrences were definitely outcrops of the bedrock. In neither case could the bottom of the flow be observed. If these are to be regarded as valley fills it would follow that the uplift took place prior to the late Miocene and that the valleys were cut approximately to their present depths by that time.

The occurrence of a deeply buried channel along the North Fork of Quesnel River is shown in the section dealing with placer deposits. Although no direct evidence as to age has been obtained this channel is in places filled with glacial materials to below the present water-level of the North Fork of Quesnel River, and the assumption is that it was cut prior to the glacial period.

On the other hand, this view is negatived to some extent by the apparent hanging relationship of the Morehead old channel, described elsewhere in this report. If this old channel be accepted as the former course of the South Fork such a relationship is difficult to explain. It is extremely unlikely that a river of this size would develop a hanging valley, under ordinary uplift, unless the valley were considered to have been abandoned prior to the glacial period. It is easy to see how such a stream could be forced aside by ice blocking its valley; its abandonment prior to the glacial period could only be due to stream piracy.

The course of this channel below the Morehead pit could not be followed. It may grade down to Quesnel River in a northwesterly direction; it has been assumed by some to cross the river, but no evidence of this was secured. The hanging relationship is inferred from the fact that between half and three-quarters of a mile from the river the bedrock of the channel is 225 feet above river-level.

This valley may, of course, be merely a pass between the heads of two small creeks formerly draining to the Quesnel system in opposite directions, in which case the hanging relationship is to be expected; the small stream (Morehead Creek) having been able to cut back a canyon in the floor of the old valley for only a short distance. That the valley was at one time occupied by a fair volume of water is evidenced by the large banks of glaciofluvial deposits.

On the whole, the evidence is considered insufficient to decide if this valley may be considered the preglacial channel of the South Fork.

The stream valleys have in general a northwesterly trend which coincides in a general way with the structural features of the region. A subsidiary northeasterly, southwesterly trend may be observed in some of the valleys.

The preglacial valleys of the major streams were somewhat wider than the present valleys, the streams being bordered by benches of glacial and glaciofluvial materials. The amount of erosion accomplished by the valley glaciers cannot be estimated, but it seems probable that in some instances at least the valleys were protected by considerable accumulations of glaciofluvial materials. The net effect of glaciation has been the filling of the main valleys with drift through which the streams have cut relatively narrow and, in places, gorge-like trenches bordered by high benches of glacial materials. These rest in places upon benches of rock, in other places the unconsolidated materials extend at least to water-level. It would appear that very low rock spurs extended into the preglacial valley and that these were not entirely removed by glacial erosion. The post-glacial streams in cutting through the glacial deposits adopted courses differing from the preglacial streams and in places cut through, and in other places exposed, the old rock spurs.

The tributary streams nearly all enter the main valleys through canyons cut either in rock or in unconsolidated deposits. The heads of the canyons mark the limit to which the tributary streams have been able to cut in keeping pace with the lowering of the main valleys. On many of the tributary streams there are two distinct rock canyons separated by stretches of more open valley cut in unconsolidated deposits. The lower canyons are believed to mark an uplift probably in late Pleistocene time. The upper parts of the smaller streams are for the most part wide, open valleys at or near the elevation of the upland surface where the effect of the rejuvenation of the streams caused by uplift has been lost. These valleys are now floored with glacial accumulations. They would appear, however, to mark the site of the early Tertiary drainage which was undisturbed by the Tertiary uplift and consequently has persisted through to the present. These valleys were all subjected to glaciation and on account of their wide-open character it would appear that their preglacial gravel content was susceptible to disturbance by ice erosion. It is possible, however, that auriferous gravels may be preserved at points in them.

PLACER DEPOSITS

The gold placers or pay-streaks occur in a number of different ways which may be summarized as follows.

(1) Ancient stream or preglacial gravels lying on bedrock and buried by thick accumulations of glacial drift. No deposits of this type where the age can be definitely proved were observed in the district, but certain deposits have been in the past considered to belong to this class and others are believed to exist. The lower gravels of the Bullion mine were considered by Dawson (3, 1894, page 24A) to be preglacial and some of the gravels of the Cedar Creek (Boe) property were classed by Johnston (6, 1922, page 81A) as probably preglacial. In both of these cases there must remain considerable doubt as to the age of the deposit. In the Bullion mine, fossil bones found in the bedrock gravels indicate a Pleistocene age. The origin of the Cedar Creek deposit is more fully discussed in the descriptive section. The bedrock gravels of the Morehead property are considered preglacial, but definite proof of this is lacking.

Preglacial gravels probably exist in the deeply buried channels of the North Fork, and Spanish Creek, but the bottom of these channels has not been explored. There is now obtainable very little data with regard to the mining carried on in the smaller creeks tributary to the Quesnel and its main branches. Such mining may have tapped in places the preglacial channels of these creeks, but it is believed that the gold was obtained for the most part from post-glacial concentrations.

The wide, upper parts of tributary valleys situated at elevations near the upland surface have previously been referred to. In the case of creeks that have been mined the gold apparently ceased at the canyons which connect these high-level valleys with the lower stretches leading to the rivers. It is considered that owing to the wide, open character of these valleys pre-existing pay-streaks may have been largely destroyed by glacial erosion. It is, however, quite possible that remnants have been preserved. The prospecting done on most of these valleys is quite limited.

Gold is also found in places on bedrock benches at different heights above the present streams. These benches carry for the most part glacial, and in some cases post-glacial, gravels. The rock benches represent stages in the cutting of the present valleys and are thus parts of old stream channels. Some of these concentrations of gold may be preglacial.

(2) The glacial gravels nearly all carry some gold, though not often in amounts sufficient to be classed as pay. In nearly all work that has taken place on huge banks of glacial gravels some gold has been recovered. It

has been pointed out that it is difficult to distinguish, in all cases, between the glacial and interglacial gravels and some of these gravels carrying gold may possibly be interglacial. So far as is known the gold in the glacial gravels does not generally occur in the form of pay-streaks, though certain instances were reported of the concentration on individual beds or layers. In some of the bench deposits of glacial gravels occurring on the South Fork rich concentrations of gold were reported, but the descriptions of these deposits, published at the time they were worked, stressed the occurrence of reworked Tertiary gravels. In general the huge banks of glacial gravels occurring at points in the district are believed to be very low grade, with the gold largely occurring as later or superficial deposits or possibly as local concentrations.

The boulder clay itself does not generally carry gold, although occasional pieces may be obtained from the washing of this material. In many places, however, the boulder clay carries numerous pebbles and boulders evidently derived from pre-existing gravel deposits which were destroyed by the advance of the ice. In the case of the Cedar Creek deposit good pay is reported to have been obtained in places high up in the boulder clay, and many instances were noted in other deposits where the boulder clay carried irregular masses of gravel. Such small sections of gravel may carry gold, but it is doubtful if pay-streaks or appreciable quantities of gold occur generally in the boulder clay.

(3) Interglacial deposits are known at several points and probably occur at others. The stratified sands and gravels lying between two deposits of boulder clay at the Bullion mine are reported to carry gold to the value of 5 cents a yard, and the boulder clay is itself reported barren. Stratified gravels on Rose Gulch, reported to carry pay, are believed to lie between two deposits of boulder clay.

(4) Post-glacial gravels are those occurring in the beds and flood-plains of the present streams and also deposited on the benches of the present streams as the streams cut down through and reworked the glacial deposits existing in the valleys. These gravels are usually thin and the pay extends down to either a true or false bedrock. Included in this type are, of course, the deposits of the bars and river flats.

Quesnel River

The main Quesnel River is formed by the junction of the North and South Forks and flows in a general westerly direction from the junction of these streams. The valley, although more open than those of its main tributaries, is still somewhat constricted by high benches of glacial materials. The preglacial valley of Quesnel River, as marked by the hill slopes above the benches, was moderately wide. The river in this stretch is swift and has a grade of approximately 12 feet to the mile.

No mining of consequence has taken place on Quesnel River in recent years. The river was worked in the early days for its bar deposits and in the last two years some work has been done on the bars and river flats.

A company was organized some years ago to dredge Quesnel River. A dredge was constructed, but no data are available with respect to its operation. The writer has not been able to secure any exact data with respect to the depth to bedrock along the main river. The ground in the vicinity of Quesnel Forks has been reported to be moderately shallow and it is also reported that some drilling was done in the vicinity of the mouth of Morehead Creek, but the results are unknown to the writer.

Properties on Quesnel River and Tributaries

Maud (Fourmile) Creek is a small stream flowing southeasterly from Maud Lake to Quesnel River. The upper part of the creek flows in a broad, northwest-southeast valley the floor of which stands at elevations of 3,100 to 3,250 feet above sea-level. About 2½ miles from Quesnel River the creek enters a canyon or relatively constricted valley which falls steeply to the river. The stream in its upper reaches is comparatively sluggish, flowing through a series of swampy meadows with a grade of approximately 35 feet to the mile, but as the canyon is approached it enters a narrow trench cut in the superficial deposits of the valley floor. The head of the canyon is marked by a waterfall of considerable height; below which the creek enters a rock-walled canyon in which it descends for about half a mile with a drop in elevation of nearly 400 feet. Below the rock canyon the valley opens out slightly and the walls are composed of unconsolidated deposits, but three-quarters of a mile downstream from the first canyon the stream enters a second rock-cut canyon. The total drop in elevation from the head of the upper canyon to Quesnel River is nearly 800 feet, an average drop of nearly 300 feet to the mile.

Maud Creek receives three main tributary creeks entering from the east and north. Two of these drain the country lying between the lower part of Maud Creek and the lower part of Kangaroo Creek and enter Maud Creek from the east in the canyon; the lower of the two enters at the foot of the lower canyon and the second at the foot of the upper canyon. Both enter through deeply cut, narrow, canyon-like valleys which climb rapidly to an elevation close to that of the upland surface. The third creek enters near the head of the upper canyon. Near the point where it joins the valley of Maud Creek it passes through a shallow rock cutting which climbs steeply nearly to the level of the upland. The upper part of the creek lies in a broad, shallow valley which continues in a northerly direction beyond the limits of the map sheet.

The upper part of this valley and that of Maud Creek itself apparently constitute depressions that existed prior to the glacial period and most likely existed prior to the uplift that preceded that period. The lower or canyon part of the creek represents the cutting that has taken place since that uplift. This cutting was probably in part preglacial, but deposits of silt and glacial materials in places on the sides of the valley indicate that the preglacial valley was filled with glacial debris through which the stream has once more cut following the retreat of the ice. This post-glacial cutting may not correspond exactly in location with the preglacial valley, but there is little to indicate where the preglacial or glacial channels may lie with respect to the present stream bed.

Mining was apparently undertaken on Maud Creek in the early days of placer mining in the district, but little information is now available with respect to this. It is reported that pay was found in the creek bed only up to the upper canyon. It seems probable that the pay thus found was obtained from post-glacial gravels occurring in the bed of the creek. It has been assumed by some that Maud Creek must cut an old channel parallel to Quesnel River to account for the concentration of gold below the falls and the lack of gold above that point. It seems more probable, however, that the lack of gold above the falls may be accounted for by the fact that above that point the creek has reworked only a minimum of the glacial materials that occur in the valley bottom; whereas below the canyon a considerable amount of these materials has been reworked by the stream cutting its grade down to Quesnel River. It is, of course, entirely possible that this post-glacial stream has cut the preglacial channel at different points between the upper canyon and Quesnel River. Owing to the fact that there is no information that would indicate the course of the preglacial channel very little can be said about the possibility of finding it. It is apparent that the lower canyon represents a glacial and post-glacial cutting where the stream has undoubtedly departed from the course it held prior to glacial times. It also seems unlikely that there is room for the creek to have passed between the canyon and the hillside to the west. The lowest tributary entering from the east flows nearly parallel with the lower canyon of Maud Creek for nearly half a mile. Over most of this distance its bed is in unconsolidated deposits, but a few hundred feet from the point where it joins Maud Creek it plunges down through a rock-walled canyon. Above the rock canyon the stream bed is dry in midsummer, but at the point where the stream bed reaches bedrock a considerable flow of water emerges. This tributary may, therefore, be cutting across the western rim of a channel of the creek which formerly flowed somewhat to the east of its present position. In other words, the creek may now be cutting across a rock spur that projected into its former valley from the west, and if this be the case, the former channel is to be sought along the eastern margin of the rock projection. The evidence must be regarded as very inconclusive, but it is deemed that a certain amount of prospecting at this point is indicated.

In the upper part of Maud Creek and also the upper part of its tributary draining Labourdais Lake it is certain that post-glacial erosion has not cut deeply enough to lay bare any preglacial deposits that may exist. The extent to which such deposits were destroyed by glacial erosion cannot be predicted, and it is only by prospecting one or more of these high-level valleys that some idea of the chances for finding auriferous deposits may be estimated.

MOREHEAD CREEK

Morehead Mines, Limited

(B.C. Minister of Mines, Ann. Repts., 1897, 1902, 1912, 1913, 1914, 1927, 1930, 1931)

The property of Morehead Mines, Limited, consists of ten leases or approximately 800 acres staked along Morehead Creek and its tributary Little Lake Creek, extending from the mouth of Morehead Creek upstream.

History. The deposits on Morehead Creek were apparently worked in the early days, partly at least, by Chinese. In 1898, twenty-five placer leases were secured by J. B. Hobson for the Consolidated Cariboo Hydraulic Mining Company. These leases covered the valley occupied by Long and Little Lakes and Morehead Creek for approximately 8 miles, but the deposit apparently was not worked at that time. In 1906 this property was taken over along with the other holdings of the Consolidated Cariboo Hydraulic Mining Company, including the Bullion mine, by the Guggenheim Exploration Company of New York and work on the Bullion continued by this company until about the end of July, 1907. In 1909 this company abandoned some of its claims, including probably the claims lying along the valley of Long and Little Lakes. In 1912 the property was acquired by the Morehead Mining Company which operated in 1913 and 1914. In 1927 the property was acquired by the Morehead Mining Syndicate and in 1930 by Morehead Mines, Limited. Preparatory work was done in 1930 and 1931 and the company started hydraulicking in 1932.

The property is situated near the lower end of an old channel that extends from near the old South Fork pit of the Bullion mine to Quesnel River at the mouth of Morehead Creek. Sections of the unconsolidated deposits found along this stretch are rare and it is only at the pits of the Morehead Mines, Limited, that the gravels overlying bedrock could be seen. For the remainder of the distance those sections available showed only the upper glacial deposits, chiefly boulder clay and glacial gravels.

The bedrock in the vicinity consists of volcanic rocks which are largely andesites. It is probable that several flows are represented. The bedrock of the pits is extremely uneven and consists of a number of natural gutters or depressions with ridges between. On this account it is somewhat difficult to determine the average grade of the bedrock; but from a survey made of the bedrock in the present pit by Mr. E. C. Annes, manager of the company, the grade was determined to be roughly 1·25 per cent. The bedrock lies at an elevation of about 225 feet above Quesnel River at the mouth of Morehead Creek. The bedrock as a rule is well worn; but in parts, particularly on the ridges, there are sharp faces.

At the point where the deposit was opened the present creek has cut a rock-walled canyon through the floor of the older valley leaving the deposit occurring on a rock bench above the present stream. The pit has been opened on the western or left-hand side of the stream; but it is reported that prospecting in the early days by J. B. Hobson demonstrated the existence of a somewhat similar deposit lying on the eastern or right-hand side of the stream.

Overlying bedrock in the pit is a stratum of rather coarse wash which is not, apparently, of uniform thickness and seems to be missing from a central high rib of bedrock. These gravels vary in thickness from 0 to 50 feet, and the pebbles and boulders consist almost entirely of the rock that forms the bedrock of the deposit—that is to say, are of local origin. No foreign boulders were noted in this lower stratum. The size of the boulders varies greatly and included in the wash are a number of large boulders, some angular, or subangular, and some well rounded. The angular boulders may possibly represent talus from the hillside rim of the deposit. The bedrock gravels are cemented, but not to the extent that they cannot be broken down by piping. Overlying the bedrock gravels is a considerable thickness of stratified gravel with layers and lenses of sand. This contains a large percentage of pebbles and rocks which do not outcrop in the immediate vicinity. The stratification is well marked, in places, by the alternation of coarse and fine material. These gravels have a thickness estimated at 50 to 75 feet in the working face, and are overlain by stratified sands and silts with a thickness of from 30 to 40 feet. The width of the channel has not been proved. A short distance above the junction of Morehead and Little Lake Creeks the former comes out of a rock canyon, cutting across what is presumed to be the main channel which extends along the Little Lake-Long Lake depression. At the junction of the two creeks, Morehead Creek swings sharply to the left and follows down along the old channel, entering a rock-walled canyon which extends a short distance below the Morehead pit. Slightly below the Morehead pit on the opposite side of the creek the bank consists of unconsolidated materials which, as pointed out before, are reported to have been prospected, giving rise to the assumption that there is here another part of the same channel or a branch of it. The material here is not well exposed owing to sloughing, but the upper part of the section consists of clay or slum and boulder clay. It is thus considered possible that the present creek has cut through a high rib of bedrock occupying the central part of the channel, leaving parts of the channel lying to the east, or it may be that a former tributary here joins the main channel. This point can only be proved by further prospecting. The bedrock of the pit lies some 60 feet above the creek bed near the pit. The distance from the pit to the western rim of the channel is not known as bedrock exposures do not occur on the bank above the pit. Mr. Annes states that by lining up the exposures occurring above and below the pit a width to this part of the channel of about 1,000 feet is expected. As there can be little doubt of the continuation of the channel upstream, the quantity of gravel remaining to be worked is very great. Until further work is done it is apparent that no definite figures can be given, but the various factors point to the existence of a body of gravels sufficiently extensive to require many years of work for their exhaustion. It should also be borne in mind that the old channel of the upper part of Morehead Creek (described as the Prior property) is probably a tributary of the main channel within the limits of the Morehead Mining Company's ground and that part of it may be considered as available for working by this company.

Values. Estimates have been made at different times, or may be made from published figures, as to the gold content of these gravels and such estimates vary within wide limits. Mr. E. C. Annes, the present manager, states that he sampled the ground carefully with the result that he considers the upper half of the gravels will average about 4 cents a cubic yard and the lower half about 40 cents; making an average for the whole deposit of about 22 cents a cubic yard. In places, in prospecting the bedrock gravels Mr. Annes obtained high values, running from $2 to $10 a cubic yard. A report made on the property some years ago, by Mr.

C. Hoffman, to which the writer had access, places the values at a much lower figure. During the years 1913, 1914, and 1915, gravels to the amount of 130,579 cubic yards were piped off with a gold recovery of $17,064, giving a value of 13·067 cents a cubic yard. In connexion with the latter figures it may be stated that it is uncertain whether all the ground worked at this time represented virgin gravels or gravels that had been partly worked by drifting. In any event the values quoted are interesting and should be well above reasonable working costs. Figures with respect to the season's production in 1932 are not available, but these, together with the yardage worked taken over several seasons, should afford a very close estimate of the contents of the remaining parts of the channel. Included in the black sand concentrates there is some platinum, native copper, native silver, and cinnabar. The platinum occasionally occurs as small pellets; native silver is rare; the native copper is known to occur in the bedrock of the deposit, usually as small pieces, but one mass 3 to 4 inches across has been found in bedrock. Copper was found during the course of geological work occurring as small masses in the rock near Morehead Lake, near the head of Morehead Creek. The occurrence of cinnabar in the rocks has not yet been established, but it probably occurs as veins or disseminations in these volcanics.

The limiting factors with regard to the deposit are grade of bedrock and water supply. At the present time the property has ample dump room, for the sluice-boxes can be gradually extended, as the creek fills up below the end of the boxes, to Quesnel River which should be capable of carrying away most of the tailings.

The grade usually required for sluice-boxes is from 4 to 5 per cent. As the grade of bedrock, so far as is known at present, is approximately 1·25 per cent the grade of the sluice-way would eventually rise above the level of bedrock, making the gravels lying below the grade of the sluice unworkable by a straight hydraulic method. There is thus a definite limit to the distance the deposit may be worked by hydraulicking. Although this limit may possibly be exceeded by lowering the sluice grade, which might be done if it were lined with steel plates, it still should be remembered that a definite limit exists.

The greatest present difficulty, however, is the matter of water supply. In 1931 the company completed the initial unit of its water supply system. This is the company's low level system, the water being derived from Little Lake, where it is impounded by means of a dam. The water released from Little Lake flows down Little Lake Creek to its junction with Morehead Creek where the water of both creeks is diverted by means of a dam to a ditch and flume and pipe-line which delivers the water to the pit under a head of 110 feet. The water thus available is not, however, nearly sufficient for a season's run. The company, therefore, has in contemplation the development of a water system using Jacobie and Gavin (Threemile) Lakes and work has been started on the project. This, when completed, will develop a watershed area of aproximately 70 square miles and will require a total of 10·5 miles of ditch and flume. The water from these lakes will be conveyed by ditches to the valley of Warren Creek and will utilize the bed of Warren Creek. Near the mouth of this creek the water will be diverted by means of a dam with ditch and flume to the property where it will be delivered under a head of 525 feet. The flow from this system is capable of being diverted to the low level or Little Lake system by way of Morehead Creek. When this system is completed it should greatly facilitate the working of the property. The low pressures at present available are not considered sufficient to work the high faces of gravel involved and the height of the face should increase rapidly as the pit is widened.

About $1,000,000 was expended in putting in a water supply system when dealing with the old channel of the South Fork of Quesnel River and it is unnecessary to repeat the discussion at this point. There would appear a strong possibility that the bedrock gravels are in part at least preglacial, although it must be admitted that there is little direct evidence of this. However, as the bedrock near the lower end of this valley stands at 225 feet above the level of Quesnel River, and as it has been shown that the present valleys were cut very nearly to their present depths before the glacial time, there is, consequently, a strong assumption that this main valley is a preglacial cutting.

The overburden has been referred to as glacial or post-glacial. It seems certain that if it be post-glacial it cannot be the deposit of the main stream, for evidence has already been presented to show that the main stream of the South Fork was diverted, first to Bullion channel and, later, the present channel, during glacial times. The relation of the stratified gravel, silt, etc., to the boulder clay at this point is not shown; the boulder clay occurs higher on the hillsides and may overlie the stratified gravels at these points, but until the pits are further opened up no evidence on this point can be obtained. Of interest in this connexion was the discovery in the pit of a mammoth tooth identified by E. H. Kindle as *Elephas primigenius*. The point in the section from which this comes is, of course, uncertain; the tooth was found on bedrock, but may have come from any part of the gravels. Again, the occurrence of this fossil does not actually prove the Pleistocene age of the deposits as it might conceivably have been washed out of glacial deposits elsewhere. However, taken in connexion with the fact that the main stream was possibly diverted during the glacial period, it strengthens considerably the theory that the stratified gravels belong to the Pleistocene and represent either glaciofluvial or interglacial deposits.

Prior's Property

(B.C. Minister of Mines, Ann. Rept., 1927)

There are some evidences of an old channel on property owned by S. Prior, situated on Morehead Creek about 2½ miles below Morehead Lake and about a mile above the junction of Morehead Creek with Little Lake Creek.

This property was worked in the eighties by R. Davis who attempted to sink a shaft to bedrock, but failed, owing to the amount of water encountered. Later, S. Prior did some sluicing, recovering fine gold from the overburden. Prior attempted to get in to the bottom of the channel by driving a tunnel from the creek level lower down, but found the tunnel was not low enough. A shaft about 12 feet deep has been put down from creek-level, but has not been sunk to bedrock owing to the amount of water encountered.

Morehead Creek above and below flows in a rock-walled canyon and apparently cuts obliquely across the old channel at this point. Until more data are available it is impossible to state the course of this channel; its direction of flow and gold content. The channel is assumed to follow down on the east side of the creek and to be a tributary to the old channel which passes by way of Prior (Long) and Little Lakes to Morehead Creek.

On the east side of the creek, lying above the shaft which is virtually at water-level, a partial section of gravel is exposed. The gravels show a considerable percentage of local wash, that is to say pebbles and boulders derived from the volcanics of the vicinity, but contain also numerous pebbles and boulders of rocks that are not known to occur in the immediate vicinity, such as granite-gneiss, aplite, granite, and quartz. Most of the gravel is medium sized and well water-worn; there are, however, a number of large boulders that consist almost exclusively of the local rock. These gravels are apparently of either glacial or interglacial origin. They are apparently overlain by boulder clay, but owing to the lack of exposures this could not be told with certainty.

Some 400 feet upstream from the shaft a large bank of unconsolidated material apparently represents the continuation of the channel on the western side of the creek. This is apparently enclosed by rock rims, and consists largely of gravel and clay, but owing to sloughing of the bank no section could be obtained.

About 350 feet downstream from the shaft, and on the east bank of the creek, a cut in the hillside shows a rock rim with boulder clay lying some distance above. Here again, owing to sloughing, little can be told about the channel.

Immediately below the shaft the creek flows in a waterfall over a rocky wall which is presumed to be the lower or western rim of the channel.

There seem to be fairly sound reasons for considering that an old channel, considerably deeper than the present creek, is here crossed by the creek. Mr. Prior states that Morehead Creek was found to be gold-bearing up to this point, but not above it to any extent. The gold content of the channel is unknown, but there is some evidence that it is gold-bearing and the larger concentration of gold may be reasonably expected to occur on bedrock.

Until bedrock is reached and the grade of the channel determined as well as the gold content there is little that can be said with regard to methods of working this deposit. Morehead Creek in this section has a grade of approximately 100 feet to the mile or about 2 per cent and it is possible that a point might be found from which a tunnel might be driven eastward to reach the bottom of the channel. The important factors with regard to the property could be determined by drilling, but unfortunately all the important water rights in the vicinity have been taken up for other properties, so that the incentive to do the necessary development work is lacking.

Birrell (Twentymile) Creek

(B. C. Minister of Mines, Ann. Repts., 1909, 1910, 1911, 1912, 1913, 1917, 1918)

Birrell Creek was worked in a small way by both white men and Chinamen, but on account of a small supply of water only limited areas were worked. The Quesnel Hydraulic Gold Mining Company was organized about 1909 to work the gravel deposits of the creek on a large scale, the assumption being that these huge deposits of gravel and clay all carried values even though lower in tenor than the small areas previously mined. Preliminary testing of the ground was reported to have disclosed values running from 5 to 8 cents a cubic yard.

About $1,000,000 was expended in putting in a water supply system and in equipping the property; the water was brought in from Swift River. The water supply system includes about 19 miles of ditches, syphon flume, etc., designed to deliver 3,500 miner's inches of water, and the source of the water, Swift River, was reported to have a minimum flow greatly in excess of that amount. The property was completely equipped in 1911 and a season's run was obtained in 1912. This showed a recovery of less than 2 cents a yard in place of the 5 to 8 cents anticipated. The property was not operated in 1913 or 1914, but in 1915 further testing was commenced.

Of this work Galloway (10, 1918, page 142) reports:

"It has now been pretty well demonstrated that the great accumulation of gravels and clays through which the present Twentymile [Birrell] Creek has cut is, as a whole, not sufficiently auriferous to pay to work. Certain terraces of gravels deposited in bays by the stream in its cutting out process, which are really partial concentrations from the older gravels, do carry values. These, however, are relatively small in extent and are such areas as were worked by the old-timers. Furthermore, it is extremely doubtful whether the values saved in the small scale testing of the ground in rockers, etc., can be saved in a short sluice carrying 3,000 to 4,000 miner's inches of water. A percentage of the values, possibly a large percentage, is in the form of flour gold which cannot be saved in the ordinary hydraulic sluice. . . . . ."

A generalized section proceeding up Birrell Creek towards the pits from Quesnel River showed the succession to be as follows: post-glacial gravels, stratified silt, stratified sand and clay, boulder clay, stratified gravel and sand, stratified sand and clay to bedrock. The strata of these different members are largely inclined rather than horizontal and for various reasons, but chiefly owing to sloughing, the thickness of the various exposures could not be accurately determined. It would appear, however, that the lower members represent outwash deposits. The lowest member consists of a finely laminated clay and sandy clay with the laminæ about $\frac{1}{16}$ inch thick. Sand occurs in beds of a foot or more thick but also possessing very distinct stratification. These apparently grade upward into the stratified sands and gravels. The boulder clay has apparently been deposited against eroded edges of the stratified gravel, but of this the writer could not be sure owing to sloughing from the top of the bank. The strata of the gravel if projected would, however, pass into the boulder clay which has the appearance of being laid down against the edges of the stratified gravels. Moreover, where the boulder clay rests on top of the gravels, the surface appears to be quite irregular, but again is concealed to a considerable extent by the sloughing of the clay from above. The boulder clay is of interest in that it contains only occasional boulders, usually well rounded, as if derived from gravel deposits.

The lower part of the section consists almost certainly of glacial outwash deposits and, therefore, is unlikely to carry gold values throughout. The writer is inclined to agree with Galloway that those parts of the deposit proved to be gold-bearing represent re-concentration from these older deposits. Although there is a chance for the discovery of a preglacial channel in this vicinity the existence of such a channel has never been proved.

NORTH FORK OF QUESNEL RIVER

North Fork of Quesnel River is a rapid stream draining Cariboo Lake. It enters the map-area in the vicinity of the mouth of Spanish Creek and flows in a general westerly direction from that point to its junction with the South Fork to form Quesnel River. The North Fork probably carries somewhat more water than the South Fork. Within the map-area this is a rapid stream and is bordered by high benches of glaciofluvial and glacial deposits. These, in places, may be observed resting on rock benches; in other places the unconsolidated deposits extend to the water's edge. The high benches bordering the stream give it a narrow, somewhat gorge-like aspect; the valley above the level of the benches, however, is seen to be moderately wide.

Considerable work has been done on the North Fork, in fact it was up this stream that the gold seekers of the early days followed the trail of gold in their search for the richer deposits in the mountains. More recent work, however, has been confined largely to the prospecting of the gravel benches. It should be borne in mind that these huge banks of material, largely glacial in origin, are deposits in which commercial gold values do not ordinarily occur. A top layer of gravel, representing the post-glacial enrichment formed as the river re-sorted and cut down through the mass, may in places represent the only profitable part of the deposit. In other places pay-streaks may occur on bedrock, representing preglacial, or, more likely, interglacial, deposits, and similar deposits may be found concentrated on strata representing false bedrock. It should be emphasized that the mere superficial occurrence of gold does not necessarily signify the occurrence of heavier concentrations of gold on bedrock. It is probable, therefore, that with such a concentration located, the average grade of any deposit, including the overburden, would be low.

Segments of an old channel, deeply buried by glaciofluvial deposits and boulder clay, are indicated at a number of points. In places the channel is separated from the river by a rim of bedrock, but the surface of this rim slopes downward away from the river, indicating deeper ground beyond the rim. This is described in connexion with several of the properties.

Properties on the North Fork and Its Tributaries

The properties on the north side of the river are described in order from the mouth of Spanish Creek down.

Quesnel Gold Mining Company

(*See also* Annual Reports of the B.C. Minister of Mines for 1924, 1925, 1926, 1927, 1928)

This company is operating eight leases on the north side of the river extending from opposite the mouth of Spanish Creek about $2\frac{1}{4}$ miles downstream. The deposits occur as large banks or benches of gravel and have been worked by means of a number of cuts put in by hydraulicking. The company obtains its water supply from two small lakes draining into the North Fork some distance upstream, known as Fivemile and Sixmile Lakes. The water supply is apparently limited to sufficient for a short run each season. Nobody was on the ground at the time of the writer's examination either in 1931 or 1932.

The bulk of the material probably represents glaciofluvial wash, with some occurrences of boulder clay and also post-glacial gravels. Although no definite statement with regard to values can be made, it is judged that the deposits as a whole are low grade.

In the upper pit of the company, bedrock was found at the head of the pit to lie quite close to the surface, and the gravels were consequently thin. The bedrock slopes steeply towards the river, however, and the gravels near the river are fairly thick, as the bench is nearly level. A generalized section showed an upper 10 feet of gravel, somewhat coarse and roughly shingled, which is believed to be a post-glacial deposit, followed by 15 feet of finer gravel with some boulders, followed by a stratum, 5 feet or more thick, of coarse gravel and boulders, and then by 20 feet of fine gravel with some boulders. Below this the cut was sloughed. A second pit nearly showed a somewhat similar section. The work on these pits was apparently done some years ago.

A considerable distance downstream, and about opposite the Hepburn pit on the Burns leases, bedrock is exposed in, and on both sides of, the river. In the cut there is a section of roughly 50 feet of rudely stratified gravels, passing upwards into 15 feet of boulder clay, which is in turn overlain by clay or slum, without boulders. Owing to the clay sloughing over the face, the section was not extremely well-exposed, although the work had apparently been recently done. It was believed, however, that the boulder clay and slum at this point were deposited against the edges of the stratified gravel, that is to say, the strata of the gravel, if projected, would pass out into the boulder clay. On the opposite side of the river, in the Hepburn pit, a similar phenomenon apparently takes place, but here again the actual relations are concealed by sloughing. It is quite evident, however, that from this point down stream boulder clay and slum form conspicuous features of the deposits, whereas upstream, as far as Spanish Creek, they are generally absent.

A cut a short distance above this is sloughed. Above there are several cuts in high banks of glaciofluvial gravels. The top stratum in some cases consists of a well-sorted, shingled wash, 8 to 10 feet thick, which is believed to represent a reworking of the glacial materials by post-glacial stream action. The glacial gravels contain a considerable number of fairly large boulders, most of which are foreign to the bedrock of the general vicinity, so far as known. They also contain a considerable percentage of "flat wash" or boulders of the typical pancake shape developed by rocks with a pronounced gneissoid or schistose structure, but flat wash was also found in some boulders of massive rocks such as porphyry. There are a number of quartz pebbles and boulders in the deposit, but these do not form any considerable percentage.

According to the information supplied by Mr. Quimby, manager of the company, the gold obtained from the property is fairly coarse and shotty, and of a rather dull yellow. The largest nugget obtained is reported at $2.50. The gold is valued at $16 an ounce. Mr. Quimby reports that good values have been found in places on bedrock, and low average values in the overburden. It would, however, appear doubtful if gold occurs throughout the overburden. It is probable that values occur in the upper gravels, and it is also possible that values may occur at various elevations in the deposits, on strata of sand or clay which might act as a false bedrock.

Matthias Gold Mining Company

(*See also* Reports of the B.C. Minister of Mines for 1925, 1926, 1927, 1928, 1929, 1930)

This company owns five leases on the north side of the river to the west of the leases of the Quesnel Gold Mining Company. The early work of the company apparently consisted of running a number of cuts in the bench deposits, which are prominent in this locality and consist of boulder clay and glaciofluvial gravels; with, probably, superficial deposits of gold. In the lowest pit, where in 1928 many thousands of yards were piped off, a section is exposed of glacial materials. The upper part of the section shows a boulder clay with a thickness of 2 to 15 feet exposed, underlain by stratified silt, approximately 4 feet thick; followed by 40 to 50 feet of stratified gravel with boulders, with the bottom of the section not exposed. The existence of an old channel was inferred at this point, which is close to a tunnel driven by Westenhiser and Wissler. It is stated that bedrock was found dipping away from the river, but this could not be verified. Work was then moved to a pit on Wolverine Creek, just above the lower canyon and 400 feet above the level of the North Fork. At this point there is apparently a depression in bedrock, which is believed by the operators to mark the site of an old channel, running somewhat parallel to the North Fork of Quesnel River and reported to have been tapped by Matthews, Boyes, and Sutherland in the first gulch to the east, known as Dry Gulch.

On the upper side of the pit, Wolverine Creek cuts across a high rim of rock in the form of a canyon. Below the pit is the lower canyon. It would appear that there are thus two rock rims trending in an easterly direction, with a depression between them. There appeared to be gravels on bedrock, but these were very poorly exposed, and on subsequent visits were covered by sloughing. These are overlain by stratified silts 10 feet or more thick, followed by boulder clay nearly to the surface, with a layer of silt on top. It is not certain that the lower silt extends all the way across the pit, for in the lower part of the pit the boulder clay appears to rest on bedrock. Although the existence of the bedrock gravels could not be definitely verified, nor could their character be seen, E. Matthews reports putting in a short drift on the rim, where the gravels are reported to be thin, platy wash, well-shingled with a considerable number of glacial erratics in the wash. The gravels are reported to be 2 feet thick, with stratified silt overlying them. Mr. Matthews reports getting only fine gold in this drive.

The stratified silt overlying the gravels is flat-lying, but at one point crossbedding was noted in it. In the boulder clay are occasional lenses of gravel. A mammoth tooth was found during the progress of mining operations, and was reported by the manager, E. G. Alexander, to come from the bedrock gravels. It was not certain, however, that these were undisturbed by mining. This tooth was determined by C. M. Sternberg from photographs to be *Elephas columbi* Falconer, and according to Mr. Sternberg, " is the first record of this species from Cariboo District."

Some gold was obtained in the piping operations, and included both fine and coarse gold. The largest piece obtained was valued at $2.50. The property was idle in 1932. No average values for the deposit were stated, but it was reported that the gold found did not amount to pay. According to miners in the district, Wolverine Creek below the point where it cuts this presumed channel has never yielded gold in important amounts.

There appears to be considerable evidence for an old high-level channel at this point. Unfortunately the pit was not in shape so that the existence of the bedrock gravels could be verified, but it appeared probable that gravels were present, and this is confirmed by Mr. Matthews' statement. It is assumed by the writer that if such a channel exists it represents a glacial or interglacial channel, for the reason that glacial erratics occur either on, or very close to, bedrock and, moreover, there is good reason for believing that the North Fork had cut below this level prior to the Pleistocene. The channel may, of course, be that of a tributary creek. The presence of the mammoth tooth, if it be assumed to come from the bedrock gravels, would indicate a glacial or interglacial channel, but fossil evidence of this character, unless found before the gravels have been disturbed by piping, is apt to be misleading.

The occurrence of a channel at this point does not necessarily prove the existence of an economic deposit. The gravels so far found are thin compared with the overburden, and the values found have apparently not been sufficient to form pay. The property is admirably situated with regard to water supply. Water was obtained from Wolverine Lake, which lies about 400 feet in elevation above the pit, and also from a number of sloughs and small streams which were diverted into the lake.

Matthews, Boyes, and Sutherland

To the east of the Matthias Gold Mining Company and some distance back from the North Fork the work referred to above was done on Dry

Gulch by Matthews, Boyes, and Sutherland. Two leases are held by these partners. According to information supplied by Mr. Matthews two tunnels were driven into the rim. The upper tunnel was 150 feet long and ran 120 feet through the rim rock and then passed out into stratified sand, which was found to be dipping into the hill. A second tunnel was started 16 feet lower than the other, but was not completed.

Westenhiser and Wissler

Immediately below the camp of the Matthias Gold Mining Company, W. Westenhiser and G. Wissler were working on a superficial deposit resting on glacial clay. The deposit occurs on a bench several hundred feet above the river. There are a number of glacial erratics resting on the clay, with gravel overlying the clay towards the outer edge of the cut. The gravel thins as the cut progresses towards the hillside, with only a foot of gravel near the top of the cut. The gold appears to be concentrated on one side of, but not under, the big boulders and is somewhat coarse and shotty. The value of the gold is reported to be $17 to $17.40 an ounce.

On the same lease a bedrock tunnel and open-cut were started near the edge of a small flat near the river, which is about opposite the Johnston property, but this tunnel had not been driven to its objective.

On the river just below the Westenhiser ranch W. Westenhiser has put in two tunnels. This work was done a number of years ago. The section at this point shows stratified sands overlain by boulder clay. According to information supplied by Mr. Westenhiser the first tunnel was 130 feet long, of which the first 70 feet were driven in a rock rim; the tunnel then passed out into glacial materials, and did not succeed in getting to the bottom of the channel on account of the difficulties encountered in holding this ground. The second tunnel is 80 feet long, and did not get through the rock rim. As these tunnels are very close to the water-level of the North Fork it is apparent that there exists behind the rock rim at this point deeper ground filled with glacial materials. The old channel of the North Fork is presumed to have crossed the river some distance above this point and to lie here on the north side of the river.

R. White

Mr. R. White was working on a bench about half a mile below the Westenhiser ranch. The deposit here consists of a post-glacial concentration on top of a false bedrock of sandy clay. The bench on which the deposit lies is between 300 and 400 feet above the level of the river, and the gravel deposit is thin, consisting of 5 to 6 feet of material evidently reworked from glacial debris, for it contains a considerable number of large erratics. The gold is mostly fine, and inclined to be flat, but some pieces are shotty in character. The water is obtained from Twomile Creek. The ground is being worked by hand methods, the gravel being shovelled into sluice-boxes. Mr. White states that the ground averaged 25 cents a yard over the period he had worked it, and that the gold content appeared to be fairly uniform.

Properties on the South Side of the North Fork

Standard Group

(*See also* J. D. Galloway (10, 1924, pages 119-124))

This group consists of eight leases situated near the mouth of Spanish Creek, four of which cover the left bank of North Fork of Quesnel River, and four extend up Spanish Creek. The bed of Spanish Creek was worked probably during the early sixties. Somewhat later deep ground was discovered on the east side of the creek and was worked by the Moore Mining Company by means of a tunnel and shafts. The property was sold to J. B. Hobson, who equipped it as an hydraulic property and worked it for two seasons. John Hopp acquired the property in 1912, but worked it for only one season, after which the ground became vacant, and was acquired by the present owners. In 1923 and 1924 the property was optioned to the Ennis Mining Company and a considerable amount of hydraulicking was done, chiefly in sluicing off the overburden. Mr. Galloway's report, already referred to, gives a very excellent account of the status of the property at that time, with recommendations as to future development. The situation with regard to the property is virtually the same as existed when Galloway made the report, as very little work has since been done.

Spanish Creek is a fair-sized stream flowing from Spanish Lake into the North Fork of Quesnel River. To the east of the creek the hills rise to a much higher elevation than is common over most of the area; to the west the upland surface corresponds roughly with that of the rest of the area. Black Bear Creek joins Spanish Creek about a mile from the North Fork of Quesnel River, and below the junction Spanish Creek flows for about half a mile in a canyon, with a steep gradient. Below the canyon the creek flattens out, and from the upper shaft of the old workings, known as the McGregor wheel-house, which is situated immediately below the canyon, the creek drops approximately 115 feet in 2,600 feet, a grade of roughly 4 per cent.

The gravels exposed in the banks of Spanish Creek represent, probably, glaciofluvial accumulations; they may, however, be in part interglacial deposits. As shown by the Ennis pit, the gravels are well stratified, with included bands of sand and clay, and near the top is a well-defined stratum of boulder clay. The height of this section of gravel is probably about 150 feet. The gravels contain a very large percentage of foreign pebbles and boulders.

The canyon of Spanish Creek is a gorge cut in bedrock. No direct evidence was obtained with regard to its age. It is assumed, however, to be either Pleistocene or Recent, as apparently an older channel of Spanish Creek passes to the east of the canyon, and is filled with glacial materials. Gravels that are believed to be glacial were noted on the banks of the canyon. Below the canyon, the creek apparently follows closely the rim of the old channel. This is apparently the western rim, and it outcrops along the eastern bank of the creek. The evidences suggesting the existence of this old channel are the drift workings of the Moore Mining Company, which include a drift tunnel approximately 1,500 feet long and three inclined shafts. These workings found bedrock much deeper than the bedrock of the present creek bed, and the bedrock on the left hand side of the Ennis pit, which probably corresponds with bedrock in the shallow part of Spanish Creek formerly worked. Although the course of the channel is naturally a matter of supposition, it appears probable that it cuts diagonally across from Spanish Creek below the canyon towards Black Bear Creek. In connexion with his report Galloway (10) refers to a plan made by J. B. Hobson at a time when the drift workings could be entered. The following excerpt is taken from his report:

"From the sections on the plan it is apparent that the Moore Company drift followed along the rim of the presumed channel and much deeper ground is shown to the east. The actual depth of the deepest part of the channel and the position of the other rim . . . . must be considered as assumed and not exact, as no workings reached the centre of the channel and no drifts were driven to the opposite rim . . . . The bedrock gravels as exposed in the Moore workings (cannot be seen now) are described in the 1902 report as follows: 'The gravel in this old channel is well water worn and flattened, carries masses of iron pyrite, white iron, pyrrhotite, and galena . . . . . . '"

The work of the Ennis Gold Mining Company consisted of sluicing off about 800,000 cubic yards of overburden in the expectation of being able to work the remainder of the channel with a drag-line scraper. The gold recovered in this hydraulicking amounted to about $2,000, but, as pointed out by Galloway, this gives no indication of the content of the gravels, as the sluice-boxes were not on bedrock, and the accumulation of boulders at the head of the sluice would act as riffles and prevent the gold from reaching the boxes. There is, consequently, no definite information with regard to the content of the overburden, other than that it contains some gold. With regard to the gold values Galloway states:

"It is known that the drift workings of the Moore Company proved that there was a bedrock concentration of gold which was rich enough to pay to work as drift diggings. Overlying this bedrock concentration there is a thickness of gravels varying from 60 to 200 feet. Assuming that it may be possible to hydraulic off these gravels down to the Moore Company workings, that is to bedrock, then it is obvious if the only gold content is the concentration on bedrock, that this streak would have to be very rich to make the proposition pay. Various figures are reported as to the richness of the bedrock ground; running from 2 ounces to 17 ounces to the set; but much richer ground than this would be necessary to pay to hydraulic off the whole mass of the gravels.

There is, however, some evidence to show that the upper gravels do carry a small gold content, distributed somewhat irregularly through them. A report by John Hobson gives an estimate of 70,000,000 cubic yards of gravel, lying above the present bed of Spanish Creek, with an average gold content of 23 cents a yard. This figure was obtained by means of testing by small pits and, therefore, cannot be accepted as being very accurate. According to Mr. Ennis about 800,000 cubic yards of the upper gravels have been removed in the pit he has operated, and from this ground approximately $2,000 has been recovered in the sluice boxes. This gives an average value for the gravel handled of one-fourth to one-fifth a cent per cubic yard."

Galloway points out that this figure cannot be accepted as the true content for the reason given above. The average content of the overburden must, therefore, be stated as unknown.

The elevation of bedrock at the McGregor wheel-house as given by Galloway is approximately 40 feet above the water-level of the North

Fork. The grade of a flume required to reach bedrock at this point would be 1·5 per cent in the place of the normal 4 to 6 per cent required. As the grade of bedrock is unknown, the grade required to reach other points of the channel cannot be predicted. It has already been pointed out that the workings of the Moore Company are on the rim of the channel, and hence if the central part of the channel be much deeper the property cannot be worked entirely as an hydraulic proposition.

Good values have been indicated on bedrock, and the upper gravels apparently carry some gold. The property, therefore, merits investigation, and such investigation should take the form of drilling, so that in the event of the property proving to have pay values some scheme for working it as a unit may be evolved. It is useless to attempt further hydraulicking on the property as the various factors, such as grade of bedrock, depth of the channel, and gold values are not known. A very considerable sum has already been spent on the property without furnishing definite information. Further work should in the first instance be directed to proving the property by drilling.

The channel on this property is probably a tributary to the deeply buried channel of the North Fork, which is indicated on the next property below. There is, consequently, every reason to expect a very considerable length of buried channel on the property.

Ruby Creek Mines

This property is situated on the North Fork of Quesnel River immediately below the Standard group, probably about three-quarters of a mile below the mouth of Spanish Creek.

The property is apparently situated on a segment of the old channel mentioned above. A rock rim, extending along the south side of the river, has been pierced by two tunnels, which pass from the rim rock out into gravels beyond. A third tunnel started has not yet been driven through the rim.

The tunnel farthest upstream is about 10 feet above the river-level, and the rim rock, which consists of black schist, holds two quartz veins 14 to 24 inches wide, which dip with the schist into the hill. The tunnel is caved at the point where it passes out into the gravels.

The central tunnel is 39 feet above the river and roughly 300 feet down stream from the first. The bedrock is schist, and the rock surface slopes downward away from the river and into the hill. The bedrock is overlain by gravels, which are mostly of small size and well rounded or water worn. A considerable percentage of the pebbles consist of flat wash which is characteristic of the gravel formed from schistose and gneissoid rocks. No strata of sand or clay are visible in the gravels overlying bedrock at the entrance to the tunnel. On top of the bedrock are both small and large, angular blocks of the bedrock, lying at different degrees of inclination to the rock, with gravels between them and the bedrock. Some of these blocks stand practically on end. There is a considerable quantity of disintegrated rock in the bottom layers of gravel, but no sign of deep weathering of the bedrock. Besides the local rock the pebbles and boulders consist of quartzite, granite-gneiss, granite, quartz, volcanics, and different types of schistose rocks.

The gravel banks extend up to the Likely-Keithley road 140 feet above, where a flat of some size exists, and they may extend higher up the hillside, but here they are concealed.

The drifting done indicates that the bedrock is still sloping downward, that is to say, the deepest part of the channel has not yet been reached.

Mr. Branston, in charge, stated that he had done some panning on the deposit, but no systematic sampling. Gold had been found over a considerable area. The gold obtained by panning is fairly coarse to fine, well-worn, and stained a rusty brown. Some is quite flat. The value of the gold is reported to be $18.50 an ounce. Concentrates assayed in Vancouver showed values in platinum up to 0·50 ounce to the ton.

It is proposed to work this property by drifting, in the first instance, continuing the tunnel as an incline until the bottom of the channel is reached. A hoist has been installed to drag cars up the incline, the cars dumping into a chute, where the material will be roughly washed on a grizzly, the oversize going to waste and the finer material to the sluice-boxes, which have been installed in duplicate, so that one set can be cleaned up without interfering with the sluicing, and equipped with undercurrents for saving fine gold. Water for sluicing will be obtained by pumping from the river. No actual mining had been carried out by this company, the work done being largely preparatory, such as cleaning out the tunnels and installing the equipment.

Burns Leases

These leases, two in number, owned by the Burns brothers, lie on the south side of the North Fork of Quesnel River between the holdings of the Ruby Creek Mines, Limited, and the Johnson property. It appears probable that segments of the old channel of the North Fork, mentioned in connexion with other properties, cross at least part of this property. No work on a large scale has apparently been done on the property for some years. During 1932 a lessee, Mr. Salisbury, was prospecting one of the leases. There are two old cuts on the property. The cut farthest upstream exhibits a section of gravels resting on bedrock some distance above the river. The elevation of the rim is approximately 100 feet (barometric) higher than that on the Ruby Creek mines, and if this be the same channel as occurs on that property, as seems likely, a higher horizon of the gravels in the channel is exposed than in the sections on the Ruby Creek ground. The top of the bench on which the road lies is 140 feet above the rim, that is the gravels are at least 140 feet thick. The gravel near the top of the bench consists of fairly fine material, and the gravels resting on the rim are well rounded and water-worn, with a considerable percentage of flat wash. A large number of the pebbles and boulders are foreign, that is, rocks not occurring in the general vicinity. There is a rough assortment in bands of coarse and fine material, but no pronounced stratification. These gravels are believed to be glaciofluvial, or possibly, interglacial.

Farther downstream is a pit known as the Hepburn pit. This pit was apparently piped some years ago, and consequently the section is not well exposed. On the eastern side of the pit is a section of gravel with thin beds of sand and fine gravel. On the opposite side of the pit there is a thickness of about 100 feet of boulder clay. This is apparently deposited against the eroded edges of the gravel—the strata of the gravel if projected would pass into boulder clay, but the actual point of contact of the two could not be seen. Beneath the gravel section there is a tunnel reported to be 190 feet long driven in the bedrock, but which did not penetrate into the channel. This tunnel is about 15 feet above high water-level in the North Fork. The cut was sluiced about 50 feet westerly from the tunnel and apparently did not reach bedrock.

It is quite possible that the old channel of the North Fork is crossed by the present channel just below this point, but no very definite data on this could be obtained.

The lessee was prospecting on a small flat lying near river-level between the two cuts. Here there is a thin deposit of gravel with a number of large glacial boulders in it. The deposit evidently consists of material re-sorted from glacial accumulations.

Moose Syndicate (Cariboo and Seattle Mining Company)

This property is situated on the south side of the North Fork of Quesnel River, about 7 miles from Likely. It is reached by a branch road from the Likely-Keithley road.

The property consists of five bench leases, and it is understood that the Cariboo and Seattle Mining Company has a contract to put water on the property, in return for which this company receives a half interest in the production. Work was in progress bringing the water supply to the property from Spanish Creek. At the same time a certain amount of sluicing was done near the lower end of the leases in 1931 and 1932.

There are indications that on this property parts of the buried channel before referred to exist, but this probable channel has not, so far as the writer is aware, been tested at any point along its course. Overlying the probable channel are benches of glaciofluvial materials and probably boulder clay occurring at elevations of 50, 100, and 175 feet above the level of the river, evidently cut, and possibly re-worked in part by the stream in cutting down to its present channel.

The syndicate has driven a rock cut towards the lower end of the leases, which passes 300 feet through the rim in the arc of a circle, and using this as a sluice piped off a considerable amount of the material overlying the rim. It appeared probable in 1932 that the bedrock inside the rim was lower in elevation than the river-level, and a number of pits were accordingly sunk to test the depth to bedrock. One pit near the head of the sluice was 10 feet deep and a bar was sunk 7 feet below the bottom of the pit, indicating that the bedrock was below the river-level. The material in this pit consisted of glacial clay, with gravel overlying it. No boulders could be seen in the clay in the test pit, but the part of the clay exposed in the banks of the hydraulic pit showed occasional boulders.

61044—8½

A few feet easterly from the head of the hydraulic pit a test hole was being sunk. At the time of the writer's visit this was down only a few feet and the material consisted of well-worn boulders in a gravelly matrix, the clay stratum had not been reached.

A third hole sunk near the river was driven to below the water-level of the stream.

The overburden is claimed to carry gold, but this is probably the result of post-glacial, superficial concentrations. Some gold may also be expected in the glaciofluvial gravels, but on the whole these are probably low grade.

The general position of the bedrock, and the test holes, together with the work done by Westenhiser on the opposite side of the river, would make it appear that the old channel is here crossed by the modern stream. It is apparent that if the bedrock of this channel lies below the water-level of the river, only the overburden can be removed by hydraulicking, and that the gravels presumed to lie in the channel would require to be elevated. No statement can be made with respect to the depth of the supposed channel, its width, or its gold content, and it would appear that before attempting to work the property these factors should be made known by means of drilling.

Murderer Gulch Group

(*See also* Galloway, 1924)

This group was not being worked at the time the writer was in the field. The following description is taken from Galloway's (10) report:

"This group of five leases is situated on the North Fork about 3 miles below the mouth of Spanish Creek; the owners are A. Rafferty, R. Tilton, J. S. McDonald, T. Comer, J. McAllister, and J. S. Day. The ground being worked lies about 50 feet above the level of the river and would seem to represent a former channel of the stream. By means of a splash or shooter dam a small pit has been opened up; the tailings are run off through a bedrock flume cut through the rim rock between the pit and the river. A section at the face of the pit shows soft, schistose bedrock, 2 feet of gravel, 2 to 4 feet of material containing large, angular boulders (slide rock), and 8 to 10 feet of fine silt. Buried deeply in this silt are remnants of old logs which are reduced to the condition of punk. It is apparent from this evidence that at least the silt-filling in the channel is of modern origin.

Some gold has been recovered from the ground-sluicing, but the average values are low. Ahead of the workings along the line of strike of the present channel there are some old workings that were made many years ago and it was reported that good pay was taken out."

In the vicinity of Murderer Gulch there are some workings on a high bench, concerning which very little information was available. The material worked appears to have been a post-glacial concentration lying on top of glacial deposits. A number of cuts were put in, but the sections once exposed are now so sloughed that it is impossible to gather much information from them. It would appear that the gold was derived chiefly from shallow workings and was concentrated on a false bedrock of sand. A considerable percentage of the gravel apparently consisted of flat wash, but a number of large, glacial erratics were also encountered.

W. F. Bendsten's Lease

(*See also* B.C. Minister of Mines Reports for 1925 and 1927)

This lease covers a small flat on the south side of the North Fork of Quesnel River, a short distance above the old bridge, now washed out. The workings lie on a low bench a few feet above the river. The ground has been prospected by means of a series of shallow pits and is between 5 and 18 feet deep to the false bedrock of sand or clay that forms the bottom of the deposit. The material is apparently a re-worked glacial deposit and consequently of post-glacial age.

A very interesting feature of the deposit is the coarseness of some of the gold. Mr. Bendtsen had a number of nuggets that would range from $3 to $8 each.

The water for working the property is brought in from Murderer Gulch by a series of ditches and flumes. The property was not being worked in 1932 at the time the writer was on the ground.

W. J. Hill Lease

This property is situated on the south side of the North Fork somewhat less than a mile from the village of Quesnel Forks. No one was on the property at the time of the writer's visit and the following information is taken from Lay (10, 1925, 1926). Surface pits show, 3 feet from the surface, a pay-streak varying in width from ½ to 6 inches under a stratum of coarse boulders and overlying boulder clay. This small pay-streak yields very coarse gold, with occasional nuggets up to an ounce in weight. Working of this lease is greatly hampered by reason of the lack of water available to the owner.

J. Shaw

(*See also* B.C. Minister of Mines Reports for 1925, 1927, 1930, 1931)

This lease is situated on the south side of the North Fork about half a mile from Quesnel Forks. The deposit is situated on a rock bench about 90 feet above the river. The bedrock consists of volcanics, overlaid by heavy gravel with some fairly large boulders, overlaid by crossbedded sands, followed by coarse gravel, fine " chicken feed " gravel, and silt. On top of the silt there is a layer or pay-streak which contains coarse gold. A number of fair-sized nuggets have been obtained from this stratum, pieces running from $2 to $11.

The lower part of the section apparently consists of glacial gravels. These contain some gold, but the distribution has been somewhat erratic. The central part of the pit, according to Mr. Shaw, gave good values right across the pit, but towards the upper end there was practically no gold on bedrock.

The coarse wash lying on top of the fine gravel and silt is believed to represent a post-glacial concentration from glacial materials, the remnants of which appear on the hillside back of the bench. The stream cutting down through these materials has effected a concentration. The heavy gold is largely confined to a thin, rusty streak of gravel in the superficial material, but even here the distribution is not uniform.

Unfortunately water is available only by impounding seepage water from the hillside and this only for limited periods. Some piping has been done by means of pumping water from the river.

Kangaroo Creek

This creek is a small stream entering the North Fork from the north slightly over a mile from Quesnel Forks. Like Maud Creek, Kangaroo Creek has a wide, upper valley and descends over a waterfall into a somewhat narrow valley, which when closely examined consists of a rock canyon about three-quarters of a mile from its mouth and a somewhat wider valley above that to the falls, 4 miles above its mouth.

The lower stretches of Kangaroo Creek show benches of glaciofluvial gravels, which are roughly stratified, but contain a considerable percentage of very large boulders, some of which are rounded and some quite angular. The creek bed contains some glacial erratics, one of which measured approximately 20 feet in diameter.

The lower rock canyon is about one-fourth mile long, and above this the creek is lined with benches of glaciofluvial materials, with an occasional spur of rock showing at the side of the stream.

Kangaroo Creek has apparently been worked from near the mouth up as far as the falls. Attention has been paid chiefly to the gravels of the valley floor, but some sluicing has been done on the bench deposits. Very little information is available with regard to this mining. The ground at the mouth of the creek was apparently quite deep, and may possibly be considered as lying over the buried channel of the North Fork. A shaft was put down near the mouth of the creek. This was reported to have been sunk some time in the seventies and to have been entirely in slum. The shaft according to reports did not reach bedrock, and was abandoned on account of the difficulty of holding the ground. Somewhat later, that is between 1890 and 1901, a drain tunnel 1,600 feet long was driven from the lower part of the creek to try and reach bedrock. This is reported to have reached a depth of 160 feet below the creek bed. The tunnel is reported to have run across a rim of rock at 700 feet and also to have rock at its end, but the bottom of the channel sought was not attained.

The creek is reported to have yielded good values, but there are no records available to the writer to confirm this.

It seems probable that the mining carried on in the past was devoted largely to the working of post-glacial concentrations occurring in the valley bottom. As in the case of Maud Creek, Kangaroo has not been reported to have yielded pay above the falls. It seems probable that after the uplift, which occurred prior to the glacial period, the stream was able to cut back in its old valley floor a certain distance, measured by the position of the falls. Later this valley was filled with glacial accumulations, through which the stream has once more cut, but in so doing has in several places exposed, or cut through, the rock spurs that projected into the older valley.

It is in the vicinity of these spurs that prospecting might conceivably reveal the existence of segments of the old channel, which have escaped attention, but it must be admitted that there is little evidence to mark the position of such a channel.

SOUTH FORK OF QUESNEL RIVER AND TRIBUTARIES

This is a rapid stream flowing northwest from Quesnel Lake to its junction with the North Fork of Quesnel at Quesnel Forks, to form Quesnel River. The distance from Quesnel Lake to the mouth of the South Fork is approximately 7 miles, and in this distance the river has a fall of 250 feet (barometric). The valley is relatively narrow and in a number of places the stream is bordered by high rock bluffs. Bars have been formed at a number of places along the stream; below the Bullion mine these are formed to some extent by the Bullion tailings and it is reported that along parts of this stretch of the stream, bedrock could formerly be observed in the river bed.

In the early days of mining very large amounts of gold were reported to have been obtained from the bars of the South Fork. Among the most famous were Dancing Bill Gulch Bar, French Bar, and Big Wheel Flat. A small amount of work was done in the summer of 1932 by individual miners on the bars and the small sections of flood-plain that lie along the South Fork. Several of these were successful in striking patches of pay-streak that had probably been overlooked in the early days or had not been regarded as rich enough to work. Although the pay on these bars was spotty, the workers reported takings of a maximum of $7 a day. This, of course, represents the maximum obtained in any one day; the average winnings of the most successful of these miners did not exceed $2 a day.

The South Fork is bordered in many places by rock benches with gravel deposits on them. These gravels are mostly glacial or post-glacial gravels, and they contain in places values in gold. These deposits represent to a very large extent reconcentrates of gold existing in glacial deposits. Mention is made in another connexion of the former channels of the South Fork, believed to be Bullion and Morehead Channels. It is believed that these either crossed the present course of the South Fork or continued along its present course, and the gold found in the South Fork, both on the benches and in the bars, represents a reconcentrate from the destruction of parts of these channels. Remnants of either of these channels may be preserved in places at either side of the valley, covered with glacial deposits, but no deposits have yet been worked that correspond certainly with these channels.

No channel deeper than the present South Fork, and following along its course has been recognized. If the theory with respect to Bullion and Morehead Channels be correct, no deep channel is to be expected, except that from a distance below Bullion Channel to the forks, where the stream would naturally grade down to meet the North Fork. It is reported at Quesnel Forks that bedrock showed up in the South Fork, and that drifting on the left-hand side of the river indicated deeper ground at that point, lying under a huge bank of glaciofluvial gravels, and that bedrock was sloping downward away from the river. These statements could not be verified. If, however, the South Fork were continually shifting its valley no deep channel could be expected, except in the stretch mentioned.

Properties on the South Fork and Tributaries

Bullion Mine

(*See also* B.C. Minister of Mines Annual Reports 1895 to 1907, 1914, 1926, 1927, 1930, 1931. Dawson, 1894)

This property is situated on the south side of the South Fork about 4 miles southeasterly from the village of Quesnel Forks.

In the early days of mining on the South Fork several rich bars were found. The pay of one of these, at the mouth of Dancing Bill Gulch, was followed up the channel of the gulch by a Chinese company working in a small way by hydraulicking. This mine was known as the China pit. A somewhat similar occurrence was operated on Black Jack Gulch by a company known as the South Fork Company. In 1892 a syndicate engaged Mr. J. B. Hobson to investigate possibilities of hydraulic mining in the Cariboo. Mr. Hobson's investigations convinced him that Dancing Bill Gulch marked the outlet of an old high run channel, which paralleled the South Fork at that point. He acquired the property for his syndicate and operated it from 1894 to 1905, during which time a total of of $1,233,936.51 in gold was recovered. In 1906 the property was sold to the Guggenheim Exploration Company and, acting for this company, Mr. Hobson proceeded to bring additional water to the property. This project was never completed; work was suddenly abandoned, the property stood idle for a number of years and was later sold. Since that time the property has been worked by a number of lessees. One of the two main ditches has been put into repair, and the property has been put into shape to work on a limited scale.

The property includes a number of leases that were believed to cover approximately 8,500 feet of an old, high channel of the South Fork of Quesnel River, separated in part from the present stream by a high rock rim known as French Bar bluff. The principal information with regard to the property is obtainable in the present pit, which is merely a continuation of the old China pit, and in the South Fork pit, which lies about 2,000 feet upstream from the face of the pit. Beyond the South Fork pit there are no exposures that would permit of determining the course of the old channel with absolute certainty. The channel as exposed by the present pit consists of a narrow gorge some 400 feet deep and 200 to 300 feet wide at the bottom and varying from 1,000 to 1,500 feet wide at the top. This rock-cut gorge lies in an altered greenstone or diabase with syenite intrusions in it. The grade of the bedrock of the channel is approximately 1 per cent rising towards the southeast, indicating that the flow of the ancient river was in the same direction as the modern river. The bedrock of the channel at its deepest part is about 170 feet above the level of the river at the mouth of Dancing Bill Gulch. The present pit is nearly half a mile in length. The bedrock of the channel is uneven, but rather well worn.

It was searched carefully for signs of glacial straiæ but none was found. The side walls have numerous sharp protuberances and faces; these may be in part due to pieces spalling off since the gravel has been removed.

Bedrock in the present pit is overlain by rather roughly stratified gravels, which have apparently varied in thickness at different places in the pit. At the present face the gravels were estimated at roughly 100 feet thick. When Dawson examined the pit in 1894 these gravels in the working of that time had a minimum thickness of 200, and a maximum thickness of 310, feet. The bedrock gravels consist of rather coarse cobbles and boulders with slide rock (?) from the canyon walls with a considerable amount of sandy gravel and clay. In general the cobbles and boulders are well rounded. The constituent pebbles and boulders consist to a very considerable extent of rocks that do not occur in the immediate vicinity and some of which have apparently been transported many miles. Pebbles and boulders of quartz, conglomerate, agglomerate, schist, volcanics, granite, and granite-gneiss were noted in addition to those formed by the immediate bedrock. The exact bedrock gravels could not be seen, owing to sloughing at most parts of the pit, but the coarser gravels occur well towards bedrock, overlain by finer material, with some beds containing numerous, coarse boulders. Some strata are well cemented by a lime cement. Crossbedding and poor sorting are on the whole characteristic of this deposit.

Following the lower gravels there is a stratum of boulder clay, consisting of a very firm clay, with only a minimum of boulders. It appeared to hold also irregular patches of gravel. The boulder clay does not occur as an even stratum across the face of the pit, but is thickest on the south side, where it rises very nearly to the surface, and thinnest on the north side. The minimum thickness is somewhat over 100 feet. Overlying the boulder clay are well stratified sands and gravels, possibly 100 to 125 feet thick at the central part of the channel, but thinning towards the southern side where the lower boulder clay approaches the surface. The strata of these sands and gravels follow in part the slope of the surface of the lower boulder clay. The top stratum consists of a normal stony boulder clay 50 feet or possibly more thick. It should perhaps be noted that these thicknesses represent estimates only, measured by eye from the bottom of the pit.

When Dawson (3) examined the pit and the South Fork pit in 1894 the top stratum of boulder clay was not present in the face of the China pit as it then existed. Dawson's section at the China pit was as follows: (1) stratified gravels, seen along part of the top of the face only, thickness about 30 feet; (2) boulder clay about 100 feet thick in what appears to represent the axis of the channel, but running out to nothing on either side; (3) rather hard, roughly stratified gravels and sands with clayey matter, maximum thickness 310 feet, minimum thickness, where the overlying boulder clay is thickest, about 200 feet. In the South Fork pit Dawson (3) gave the section as follows: (1) ordinary boulder clay, with many glaciated stones, 60 feet; (2) stratified sands and gravels, 120 to 130 feet; (3) hard, lower boulder clay with very few glaciated stones, 30 feet; (4) well-rounded gravels to bedrock, 30 feet. Dawson pointed out the probable equivalency of (1) of the China pit with (2) of the South Fork pit, (2) with (3), and so on and stated " it would appear that the lower and richer deposit in each pit is preglacial while the upper gravels in the South Fork pit (2) are actually, and those of the China pit (1) are probably, of interglacial origin."

The section at the South Fork pit is not now well exposed as the pit has not been worked for a number of years, and the banks are to a considerable degree covered by sloughing. The upper boulder clay and upper stratified gravels can be seen and the presence of the lower boulder clay inferred from the clay at the bottom of the pit, but the bedrock gravels cannot be seen.

Values. Undoubtedly the best measure of values of the Bullion is the quantity of gold recovered and the yardage worked. From 1894 to 1905 the figures were published annually and the gold production was $1,233,936.51 which was recovered from somewhat over 12,000,000 yards of gravel, an average of 10 cents a yard. This figure may possibly be a trifle low, as Hobson's sluices passed above bedrock, leaving a wedge of gravel below the sluice. A bedrock tunnel put through the rim from the South Fork has brought the sluices once again below bedrock, and part of this wedge of gravel has been removed. No figures as to production and yardage worked have been published by any of the subsequent operators, but it is not believed that sufficient yardage has been worked since 1905 to materially affect the average.

There is a wide difference of opinion amongst those who have worked the Bullion as to the actual location of the gold in the deposit. It would appear that the bulk of the gold lies in the gravels below the lower boulder clay, but the upper gravels also carry values. According to Dawson (3) Hobson placed the value of these upper gravels at 5 cents a yard. The lower gravels must, therefore, have carried considerably in excess of the 10 cents a yard obtained as the average of the deposit, for the boulder clays are believed barren, or very nearly so. It is reported by some familiar with the property that the best values are obtained high up in the lower gravels, and this would appear to be borne out by recent testing of the face; but some gold does occur in the lower part of these gravels. There can be little doubt, from his reports, that Hobson believed the lower gravels to be rich, and the fact that the bedrock gravels of the South Fork pit, reported by Dawson (3) to be only 30 feet thick, are also reported as rich in gold (this from test pits dug) would tend to disprove that there is any general tendency of the pay-streak to rise above bedrock.

Mining. The deposit was worked as an hydraulic property, the early sluice being brought into the pit by way of Dancing Bill Gulch. As the sluice continued up the pit on a 5 per cent grade, whereas the grade of bedrock is only 1 per cent, eventually the sluices passed above bedrock, leaving a wedge of gravel lying between the sluice and bedrock. To overcome this a tunnel was started through the rim from the South Fork, to come under the centre of the pit, and from which sluice grades could be obtained to work the bedrock gravels for a considerable distance on either side of the tunnel. It is estimated that this grade will permit the gravels being worked far enough ahead so that the remainder, lying between this point and Black Jack Gulch, could be sluiced through this opening. The sluice tunnel is about 1,200 feet long.

The breaking down of the bank is done entirely by water, but bank blasts have been used in the past to break up the lower boulder clay, which is apparently somewhat indurated and difficult to break up with the water.

Water System. When the property was taken over by the original syndicate a water system, taking the water from Polley Lake and Bootjack Lake, was constructed. This water was brought to the property in a ditch system some 19 miles in length; but was found insufficient to work the property and a second system, taking water from Morehead Lake and entailing the construction of 11 miles of ditch and flume, was added. Apparently several dry seasons towards the latter part of Mr. Hobson's regime interfered seriously with the working of the property and when it passed into the hands of the Guggenheim Exploration Company a projected scheme to bring water from Spanish Lake was proceeded with, but never completed. It is stated that this meant the cutting out of part of the Polley Lake ditch, but in any event the property stood idle for a number of years, and the ditches, and more particularly the flumes on them, deteriorated. When the property was reopened, the Morehead system was restored and shortened by taking the water out by way of Jawbone Creek. The water from Bootjack Lake was also diverted to throw into Morehead Lake instead of into Polley Lake. The Polley Lake ditch has not been put into repair. The property is thus left with only a part of the water that was available when worked on an extensive scale. The water now available is not sufficient for a full season's run even under good conditions, and in dry years would fall far short of requirements. The cost of re-establishing the Polley Lake system would be considerable. The estimate of the cost of the Spanish Lake system, made when that supply was contemplated, is given in the reports of the Minister of Mines for 1906.

Character of the Gold. The gold in this gravel is reported to be generally fine, well-worn, and flattened, varying in size from fine colours to that of flax and melon seeds, but large pieces worth $4 and $5 are also found. In the sluice concentrates a small amount of platinum is reported.

Economic Considerations. There can be little doubt of the continuity of Bullion Channel for some distance beyond the present face. The channel is virtually proved as far as the South Fork pit and may extend for some distance beyond, as it is supposed to have been found in the gulch next upstream from Black Jack Gulch. There is thus still a very large yardage of gravel remaining. Beyond the present pit face the ground slopes away towards Black Jack Gulch, and as the bedrock is rising this should mean considerably less yardage to be worked a running foot of channel. It is possible, however, that the channel widens at this point. It is not known whether the decrease in yardage indicated per foot of channel means a consequent increase in the value a cubic yard, as the testing of the bedrock gravels in the South Fork pit, quoted by Dawson, showed these to be fairly thin, but rich in gold. This channel is worthy of a complete testing to see if the expense of putting an adequate water supply on the property is justified, as it seems probable that with water available the ground could readily be worked for the gold values that have been obtained in the past.

Age. Bullion Channel has sometimes been loosely referred to as part of Morehead Channel which passes by way of Long and Little Lakes to Morehead Creek. The grades of bedrock if projected to the point where these two come together would show that the Morehead is a much higher level channel, and that both drain in the same direction. If the two be considered as old channels of the South Fork, although it is by no means certain that they are, it will be apparent that the Bullion is an intermediate stage between Morehead Channel and the present stream. It is not at all likely that both can represent the preglacial channel of this one stream; to assume this would be to infer the capture of a main river tributary to the North Fork, by a much smaller stream also tributary to that river. It would appear more likely that if Morehead Channel represents the preglacial channel of the South Fork, it was turned aside by ice or glacial accumulations from its older valley. There is ample evidence that Bullion Channel was rapidly cut and rapidly filled. The gorge-like character of the valley is ample evidence of the rapid cutting, and the cross-bedded and poorly sorted character of the lower gravels evidence of its rapid filling. Dawson considered these lower gravels preglacial, based largely on the fact that they occur beneath the lower boulder clay. The gravels are, however, made up quite largely of boulders that are not derived from the immediate vicinity, and some that are entirely foreign to the area. Although boulders can undoubtedly travel long distances in a swift stream, the large number of these foreign boulders is interpreted as indicating that they came from the erosion of glacial deposits elsewhere. Fossils have been found from time to time in the Bullion pit. The care with which these must be used has already been pointed out, but in one instance the skull of a Rocky Mountain goat was found in raising from the bedrock tunnel through the lower gravels, and was consequently in place in the section. This form, discussed in the section dealing with unconsolidated deposits, is believed to indicate a Pleistocene age. There is thus considerable evidence for assigning the lower gravels of the Bullion to the Pleistocene rather than to the Tertiary. Their occurrence below the lower boulder clay at this point may merely mean that the channel was cut following the retreat of an earlier ice-sheet, or a valley glacier, and was partly filled before the next advance of the ice. No more than two boulder clays have been recognized in a single section in the area, but the equivalency of a boulder clay at one point with that at another is difficult to establish, so that more than one interglacial period may have occurred.

No other properties, other than bar diggings, were being worked on the south side of the South Fork. Near Likely, drilling was in progress on a bench on the south side of the river, and a considerable thickness of glacial materials and gravel was indicated. This work had not been completed to the stage where any conclusions could be arrived at with regard to the property.

Properties on the North Side of the South Fork

Halfmile Creek

This gulch enters the South Fork about half a mile from the village of Quesnel Forks. On the western side of the creek about 300 feet above the river is an old Chinese hydraulic cut, which has apparently been abandoned for a number of years. The cut is now sloughed to such an extent that no section of the gravels could be obtained. The gravels seen were believed to be glacial or reworked glacial gravels.

On the opposite side of the gulch and slightly higher up are workings on a lease owned by Messrs. Nuitio, Laitinnen, and Sedley. These consist of a cut, worked largely by hand, with the material shovelled into boxes through which the water of the creek is diverted. The bedrock of altered volcanics is exposed in the upper side of the cut. The unconsolidated deposits consist of 5 to 6 feet of stratified sand and gravel, containing occasional large boulders, followed by boulder clay. So far as is known the gold is confined to the stratified gravels and does not occur in the boulder clay. The gold is medium to coarse in size, with the largest pieces obtained running between $1 and $2. The owners state that the ground worked showed an average of about 25 cents a yard.

About 460 feet above the river a cut has been put in, apparently many years ago, and a tunnel driven into the hill. The object of this work was evidently to reach a presumed high-level channel, supposed to lie between the North and South Forks of Quesnel River, coming out to Quesnel River at Quesnel Forks. The results obtained in this work are not known.

On the benches of the South Fork between Halfmile Creek and Rose Gulch considerable work has been done on shallow gravel deposits that are believed to be post-glacial. The results obtained in this work are unknown to the writer.

Rose Gulch

(*See* B.C. Minister of Mines Reports 1896 to 1898, 1900, 1902, 1925, 1926)

Rose Gulch is a small stream draining a small lake to South Fork of Quesnel River, entering the river 1½ miles above Quesnel Forks. Considerable work was done on this gulch between 1895 and 1902, but there is very little published information about this. At the present time T. W. S. Taylor and A. Burns hold two leases extending up the gulch from the Quesnel Forks-Likely road to Rose Lake.

The gulch for part of its course cuts across an old channel and most of the mining done on the creek has been devoted to the hydraulicking of the gravels in this channel. Some work was apparently done on the gravels in the bed of the creek, but no record of this was obtained. The hydraulic workings have exposed a series of sections in the unconsolidated deposits along the lower part of the creek. Between the river and the lowest pit, the creek flows across a rim of greenstone. The pit lying lowest on the creek is on the northern side and shows 60 feet of boulder clay, apparently extending to bedrock, followed by 20 to 30 feet of poorly stratified gravel, followed by 6 to 10 feet of sandy gravel. The present working face of the pit is in stratified gravel, which is well cemented. On the opposite side of the gulch, and somewhat higher up, a second pit has been hydraulicked off, apparently some years ago. Here the bedrock is exposed on the downstream side of the pit. The lower part of the section is covered by sloughing, but the centre of the pit apparently did not reach bedrock. The part of the section exposed consists of 20 feet of stratified gravel, overlain by 8 to 10 feet of stratified silt, overlain in turn by boulder clay.

On the north side of the creek are two pits, one of which is badly sloughed, and the other shows stratified gravel overlain by boulder clay.

On the south side of the creek is the final pit of the series, which shows about 30 feet of stratified gravel, with beds of sand ranging from a few inches to a foot thick. The gravel is mostly small and well water worn, with no large boulders showing in the section. On top of the gravel is a layer of sand with coarse, angular blocks of the country rock, followed by a stratum of clay with similar blocks. This is followed by a stratum of silt, which is in turn followed by a boulder clay.

Although the two boulder clays mentioned were not seen in the same section, the evidence appears fairly strong that the stratified gravels are to be regarded as interglacial, or possibly in part, glaciofluvial.

According to Mr. Taylor, the gold obtained is fairly coarse and is confined to the stratified gravel.

The property is worked by hydraulicking, the water being brought in a ditch from higher up the gulch. The quantity of water is apparently sufficient to work the property for only part of the season.

This high-level channel has not been definitely related to other channels occurring in the vicinity. It has at times been referred to as the continuation of Bullion Channel, but the bedrock is about 100 feet (barometric) above the bottom of the Bullion mine.

Nelson Leases

Three leases owned by R. O. Nelson are situated close to Big Wheel Flat, about 3 miles downstream from Likely. This property was being worked in 1931 and 1932 by means of a pump hydraulic outfit.

The work is being done on the lower of these leases, where three cuts have been run in a short distance from the river. The present work is on the cut farthest upstream. Below the cuts, at a bend in the river, bedrock rises to a considerable height above the river, and some distance above there is also a rock bluff. On the bench overlooking the river between these points several shafts have been sunk to bedrock, indicating depths ranging from 31 to 40 feet. According to information supplied by Mr. Nelson the shafts encountered a stratum of sand up to 15 feet in thickness, followed by gravel to bedrock. Good prospects were reported throughout the gravel in these shafts. At the site of the cut being worked, a tunnel was started into the bank on bedrock. The floor of the cut is about 20 feet above the level of the river, and has been advanced some 50 feet from the river. The section from the surface is as follows: fine gravel and sand 10 feet; fine gravel with some heavy boulders 15 feet, roughly stratified; a layer of heavy boulders; coarse gravel 10 feet. The lower gravel is cemented with a blue clay containing fine gravel, but this cemented material can be cut with water. The larger boulders are mainly foreign to the vicinity. Other pits downstream showed, as far as could be observed, very similar sections. Mr. Nelson stated that the prospecting done to date showed average values of 30 cents a yard. A considerable percentage of the gold is fine, but not flour gold, and the largest pieces range up to 50 cents or $1 in value. The concentrates obtained contain much pyrite and are reported to be high in gold. Platinum values up to 0·42 ounce a ton are also reported from the concentrates.

The property is supplied with water by means of a pump and Diesel engine, but the quantity of water and the pressure are not sufficient to move a considerable proportion of the boulders, which have consequently to be moved by hand.

There is probably a considerable body of gravel lying on this bench, and if the values measure up to those reported by the preliminary prospecting, little difficulty should be experienced in working the property, if an adequate supply of water be made available. The deposit probably represents a reconcentration by the post-glacial stream from glacial and other materials that formerly filled the valley.

On the ridge lying to the north of the South Fork of Quesnel River considerable prospecting has been done with the idea of picking up an old channel that is supposed to lie on the bench. Along the edge of the bench prospects have been obtained at a number of points and considerable work in drifting and in shaft sinking has been done.

Foley Lease

This lease, owned by L. G. Foley, lies northeast of the Nelson leases and a quarter to a half mile back from the river. The workings are situated about 340 feet above the level of the river. Here, near the edge of the bench, bedrock is exposed, but the surface of the bedrock apparently slopes into the hillside. A short distance back from the edge of the bench Mr. Foley has put down a shaft 15 feet which is reported to be in fine, sandy gravel, not apparently stratified. Other shafts up to 9 feet deep were sunk, but bedrock could not be reached owing to the water encountered. The fine, sandy gravel is reported to give colours of gold. A cut has been started from the bedrock exposure, proceeding up a small gulch, but the bedrock shows only at the lower end of the cut. The upper part of the cut is in boulder clay. At the corner of the cut where bedrock is exposed Mr. Foley states he obtained coarse gold. On the hillside at an elevation of approximately 100 feet below the cut a tunnel has been started through the bedrock in an effort to get into the bottom of the depression that apparently exists in the bedrock at this point, but has not progressed far enough to reach its objective.

Adjoining the Foley lease on the east are two leases owned by D. McChesney. On these leases a ground-sluice is being run in a small gulch that crosses the property. The material in the cut consists of boulder clay. Some gold was reported to have been obtained from the cut.

On the adjoining lease T. Boyes has sunk several shafts back of the presumed rim. These shafts were partly filled with water and could not be examined, but the material on the dumps suggested that these workings were in boulder clay. The shafts did not reach bedrock owing to the water encountered. A tunnel has been started from the hillside at an elevation of 150 feet below the lower, and 230 feet below the upper, shaft. This tunnel, 170 feet long, passed through cemented gravel for about 80 or 90 feet and through rock for the balance of the distance. It has not been carried far enough to get under the bedrock depression indicated on the surface. A short distance west of the tunnel an open-cut has been excavated in boulder clay. This cut exposes a tunnel evidently put in by old-time miners. About 100 feet below the tunnel a ground-sluice exposes post-glacial gravels 8 to 10 feet thick lying on bedrock some 50 feet in elevation above the South Fork. Good prospects in gold have been reported to have been obtained here.

On the adjoining lease to the east A. Carvillet has also driven tunnels at about the same elevation as the Boyes' tunnel. These have not been completed.

A number of leases are held on the hillside back of the village of Likely, extending along the hill to Poquette Creek. In most instances no work was being done on the properties during the periods when the writer was in the district, so that much of the data required with regard to the properties could not be obtained. The placer deposits consist generally of shallow gravels lying on the slope draining down to Quesnel Lake and are considered to be largely glacial deposits. Galloway (1923, page 127) reports the presence in places of well-weathered gravels considered to be Tertiary gravels reworked by glacial and stream action.

In the vicinity of Excelsior Gulch a number of cuts have been put in. These are reported to lie on the Carvillet lease. In the lower cut bedrock is not exposed and the material in which the cut has been made consisted of boulder clay containing large, angular blocks of limestone. A short distance to the southwest a second cut, also in boulder clay, exposes the bedrock, consisting of interbedded argillite and limestone, at the lower end. On Excelsior Creek itself a cut starts about 330 feet above the level of the creek and proceeds upstream for several hundred feet, terminating at an elevation of 450 feet above Quesnel Lake. Bedrock is exposed in this cut over most of the distance and is overlain by boulder clay 30 to 40 feet thick. A considerable percentage of the boulders in this material consist of rounded pebbles and boulders, but the material contains also some large, angular boulders. The matrix is clay or gravelly clay. This cut has encountered a tunnel evidently put into the hillside many years ago. No details are available as to the character, amount, or location of the gold recovered.

On the Morrison lease are several old cuts that are badly sloughed and overgrown. The gravels are apparently glacial, containing numerous large erratics. The gravels exposed are fairly thin, ranging from 6 to 15 feet, and in one of the pits the gravel deposit is overlain by a thin layer of marl containing recent freshwater shells followed by soil. One of the cuts was being worked by means of a rocker and according to reports two different classes of gold are found—the one bright and the other rather dull and reddish with iron stain. The gold is reported to occur above, not on, the bedrock. The gold actually seen was mostly fine, but nuggets ranging as high as $4 in value are reported to have been obtained. According to reports this lease was worked some sixty to seventy years ago and very good pay obtained.

On the adjoining lease, known as the Thompson lease, there are cuts near the edge of the bench overlooking Quesnel Lake. The materials here consist of shallow glacial gravels, but Galloway (1923) reports the inclusion of weathered Tertiary gravels probably reworked by glacial and stream action and mixed with glacial gravels. No information was obtained with regard to the gold content.

Kemp and Lackie Leases

(B.C. Minister of Mines: Ann. Repts., 1925, 1927, 1928, 1930)

These leases, extending up Poquette Creek from Quesnel Lake, are reported to have been bonded by B. Boe. The deposit lies on the slope facing Quesnel Lake, the lower part of the workings being about 75 feet above the lake. Two pits have been excavated along this slope and show that the bedrock slopes towards the lake fairly steeply. The bedrock consists of interbedded limestone and argillite, intruded by greenstone, and is hummocky and uneven but worn fairly smooth. The material overlying bedrock consists of glacial gravels. Near bedrock the pebbles are generally small and rather angular, but still somewhat worn; a considerable number of large boulders occur. The matrix is a sandy clay and the lower part of the deposit is so tightly cemented as to require shooting before it can be piped. In the upper part of the section the gravels are less coherent. A considerable percentage of the gravel consists of red syenite which is typical of the gravels along part of Poquette Creek. The large boulders, some of which are well rounded and waterworn, are composed of rocks showing a wide diversity of types, many of which are foreign to the area. The gold is reported to be coarse and little worn. A large number of seams of quartz and calcite traverse the bedrock in the pits, but no free gold was observed in this nor was any sulphide mineralization apparent. Some fine gold is obtained from the less coherent top gravels.

The water for working the property was brought in a flume from a diversion and storage dam on Poquette Creek, situated just above the mouth of Likely Gulch, but this dam was destroyed in 1932 and the stored water escaped by way of Poquette Creek.

On Poquette Creek, some distance to the north of the last working, a pit has been opened at the head of the rock canyon through which the creek descends to the lake. This work is reported to have been done by B. Boe under lease from Lackie and Kemp, but as no one was on the ground at the time of the writer's visit few particulars could be obtained.

The pit is situated about a third of a mile below the mouth of Likely Gulch. At the lower or downstream end of the pit the bedrock forms a high rim, the surface of the rock sloping downward upstream. Deposited against this rim in ascending order are 30 feet of roughly stratified gravel, 10 feet of gravel with large, angular boulders, and 10 feet of stratified silt. The strata of these are not horizontal but conform in a general way with the slope of bedrock, that is to say they are dipping upstream. In the lower gravel large, angular boulders are not common, but the constituent pebbles of the gravels on the whole are angular to subangular. The stratification of the deposit is only very roughly marked. Overlying these lower gravels is a stratum approximately 10 feet thick in which there is a very considerable percentage of coarse, angular boulders. The stratified silt upstream from the pit contains a considerable number of angular boulders which possibly represent slide rock from the neighbouring hillsides. No information was secured relative to the gold content or gold distribution in these gravels.

It was originally thought that the lower Lackie pits represented a continuation westward and southward of an old channel of Poquette Creek, but the work done apparently disproves this. The gravels shown in the various cuts are quite evidently glacial. Lay (1925, page 159) makes reference to the presence of Tertiary gravels (probably reworked) in the lower part of the deposit.

Poquette Creek

Some work has been done on the smaller tributaries of Poquette Creek. On the stream lying immediately to the south of Likely Gulch some workings were encountered in the bed of the stream. These consisted of a shaft and cut, but bedrock had not been reached and the workings were apparently in boulder clay.

Considerable work has been done on Likely Gulch a short distance above its mouth. It is reported (B.C. Minister of Mines, 1902, page 85) that J. B. Hobson purchased this ground from a Chinese company that had previously done considerable work in 1901 and tested it during that year. The cut is now so filled with debris that little information could be obtained. It is reported, however, that coarse gold was obtained from these workings. This lease is now reported to belong to Mrs. Violet Huston.

Above the cut on the southern side of the gulch W. Eop has driven two tunnels at an elevation of approximately 430 feet above Quesnel Lake. These tunnels were driven to try and tap an old channel presumed to lie to the south of the gulch. It is reported that these tunnels passed through rock out into gravel, but no particulars as to the work or results were obtained.

On several of the other tributaries to Poquette Creek work is being done on what are presumably post-glacial concentrations in the creek beds. On the eastern side of Poquette Creek there is a large tract, with a surface showing relatively little relief, which is believed to represent a part of the old Tertiary erosion surface. Exposures of the unconsolidated deposits in this area, made largely as the result of mining excavations, show that it is quite extensively underlain by boulder clay.

On a small creek locally known as Fivemile Creek, Acheson Lucey has put in a small cut in gravel which has likely been derived from reworking of the boulder clay. The cut shows large boulders of a number of different kinds of rock in well-washed, rounded gravel. Mr. Lucey reports the gold obtained to be moderately coarse and the ground, so far as tested, to show a content of about 30 cents a yard.

Muir and Thom Leases

These leases, five in number, are owned by Mr. and Mrs. Colin Muir and John Thom. Three are situated along the valley of Beaver Creek, with the other two adjoining to the north. The leases lie to the west of, and adjoin, some of the ground of the Cedar Creek Placer Gold Mining Company, Limited.

Beaver Creek is the name locally applied to the first small creek lying to the north of Cedar Creek. It rises on a prominent bench lying to the north of Cedar Creek and flows into Quesnel Lake, where its entry is marked by a small delta and alluvial cone. The lower part of Beaver Creek above the delta is cut in a canyon in granodiorite. At the top of the canyon the ground flattens out in a small bench and then rises in a second bench. The bedrock is exposed at the edge of the first bench in the mining excavations and at this point the workings have exposed a stratified sandy clay or "slum" overlying the rock. The surface of the rock apparently slopes rapidly downward at this point and the stratifications of the slum follow in a general way the slope of the rock, being inclined to the horizontal at considerable angles. A short distance back from the rock outcrops gravels 6 to 8 feet thick lie on top of the slum. A shaft has been sunk 23 feet, but did not reach bedrock owing to the water encountered. The greater part of this shaft was sunk in the slum.

On the slope above this bench a cut has been put in exposing boulder clay lying some 50 to 100 feet higher than the gravels mentioned before, but the relations of this to the gravel are uncertain. In the gravels there are streaks of fairly coarse wash that are reported to carry fine gold.

The work is being carried on in the expectation of finding an old channel crossing the bench that lies to the north of Cedar Creek, possibly a continuation of the old channel of Cedar Creek. There seems to be very good evidence of a depression existing in bedrock where the prospecting has been carried on, but the work done to date is certainly not sufficient to permit of saying that this depression marks the site of an old channel. Although the relations are obscure, it seems entirely probable that the gravel encountered on top of the slum is more recent than the boulder clay occurring higher on the hillside and represents a post-glacial concentration from the boulder clay.

On Fisher Creek, which is the next small creek north of Beaver Creek, A. McLeod has one creek lease about 450 feet above the level of Quesnel Lake. This deposit is also situated at the edge of the bench where the creek makes a rapid descent down the slope to the lake below. The deposit consists of boulder clay which contains a very large number of rounded boulders presumably eroded from stream gravels elsewhere. The gold, according to Mr. McLeod, occurs in streaks from 1 to 1½ feet thick on bedrock, chiefly where inequalities in the bedrock make depressions. Mr. McLeod also reports obtaining fine gold from the boulder clay. The workings consist of an open-cut several hundred feet long.

Cedar Creek

(Johnston, 1922; Galloway, 1921 to 1924; Lay, 1925 to 1931; Dolmage)

Cedar Creek was mined to some extent in the early days of placer mining in the Cariboo. Johnston quotes from Bancroft's History of British Columbia, showing that the creek was first prospected in 1862, but owing to the discovery of rich placer ground in Barkerville district, was abandoned until 1865 when real mining commenced. This mining was apparently confined to the lower part of the creek above the delta and did not extend more than a mile upstream. It would appear that the workings were confined largely to the bed of the stream and that the best of the ground was rapidly exhausted, for Dawson (3) notes (1887-8) that the creek was largely in the hands of Chinese miners. Johnston (6) estimates the production of the creek prior to the recent discoveries as not exceeding $100,000.

In the autumn of 1921 placer gold was discovered on the bench to the south of Cedar Creek by A. E. Platt and J. Lynne. Owing to faulty location the actual discovery proved upon survey to lie upon the lease of E. G. Stevens. In 1922 six of the original stakers pooled their interests and bonded them to the Cedar Creek Mining Company. This company operated the ground until May of the following year, when it went into the hands of a receiver. Various leases and options followed, but there was no continuous operation by any one party until 1928 when B. Boe secured a lease on the property, since which he is reported to have purchased it.

Cedar Creek is a small stream crossing the eastern boundary of the map-area. In its lower part for about $1\frac{1}{2}$ miles from the delta in Quesnel Lake, near its mouth, the creek flows through a narrow, steep-sided, V-shaped rock gorge. This gorge is roughly 400 feet deep, and the sides, although not vertical, are in many places so steep that they cannot be readily climbed. The grade in this part of the creek would approximate 8 per cent or roughly 400 feet to the mile. The upper part of the creek flows in a broad, flat-bottomed valley that is nearly parallel to the valley containing the lower part of Quesnel Lake. The change from the canyon to the broad valley is not abrupt, but gradual, the more recent cutting being marked by a shallow, V-shaped notch in the valley floor, which deepens as the canyon is approached. The upper part of the stream lies off the edge of the map-area, but apparently flows in a series of meanders in a series of meadows with relatively little grade. A flat-topped ridge, probably an erosion remnant, lies between Cedar Creek and Quesnel Lake, and is from 900 to 1,000 feet above the level of the lake. Between Cedar Creek and Spanish Lake, which lies to the east, is Spanish Mountain. The broad valley of the upper part of Cedar Creek thus corresponds in direction with the main valleys in the vicinity, but on entering the canyon the stream turns at nearly right angles, and flows southwest to Quesnel Lake.

At the mouth of the rock gorge there is an alluvial fan merging into Cedar Creek delta, which apparently represents the bulk of the material removed from the gorge of Cedar Creek since the retreat of the ice from Quesnel Lake basin. A comparison of the size of these with the gorge itself would indicate that part of the canyon was cut before the last retreat of the ice from the region, and this view is strengthened by the presence of glacial drift in places on the sides of the canyon. It would appear probable that the initial cutting of the canyon began with the preglacial uplift before referred to, and that the canyon has been deepened in glacial and post-glacial time. The upper part of the valley corresponds closely with the level of the upland surface in other parts of the area.

The rocks exposed in Cedar Creek Canyon and elsewhere by mining operations beyond the margins of the canyon consist of volcanics.

The early workings on Cedar Creek were confined largely to gravel deposits in the bed of the stream. There is little data available with regard to these workings. Johnston (6, 1922, page 12A) quotes Bancroft as follows: "The Cedar Creek diggings proved to be valuable, yielding steadily as well as largely for some time. The Aurora claim, with flumes and sluices costing $8,000, yielded, mostly in 1866, $20,000; the Moosehead claim, costing $2,000 to open, paid $7,000 the first year; the Barber claim, also located in 1866 and costing $7,000 to open, paid $2,000 in a year; and the discovery claim was yielding in September, 1866, $15 to $20 a day at a point where it was shallow. In August, 1867, the Aurora was paying 100 ounces a week, and the other claims from $10 to $20 a day to the man." Dawson (3) reported in 1887 that the creek was largely in the hands of Chinese who worked it for some time on a fairly extensive scale.

The workings, as stated, were confined largely to the creek bed; in a few cases benches up to 100 feet above the level of the stream were worked. The creek gravels worked were apparently post-glacial; it is possible, however, that some of the benches included glacial or interglacial accumulations. Judging from the old workings and also from information received from residents of the district, the pay on the creek did not extend above the draw on which the discovery of 1921 was made. There is very little information about the creek above the point where the workings stopped. Some holes have been put down in the upper part of the creek and, according to reports, have encountered only fine gold.

Only one property was working in the canyon of Cedar Creek in 1932, the Rob Roy Mining Company, with E. S. Esland in charge. This property is the lease of M. Donohue. It is situated about half a mile upstream from the delta, and is about 200 feet above it in elevation.

The workings are on a small bench 40 to 50 feet above the creek level which was prospected by Mr. Donohue by means of a tunnel driven in on bedrock. According to information supplied this tunnel was driven 87 feet and did not fully crosscut the old bench channel. The slope of the surface of bedrock was stated to be away from the creek. Good values are claimed in this preliminary prospecting.

The gravels may be divided into two parts: the lower consisting of fairly coarse to medium-sized boulders, with large, angular blocks of the bedrock, which, however, on close inspection all show some signs of wear; and an upper section consisting of "chicken feed" gravels possessing a rough stratification. The matrix of the lower gravels consists, partly at least, of small, angular pieces of bedrock and fine, sandy clay. Both types exhibit numerous boulders that are foreign to the immediate locality, such as schist and granite-gneiss. The gravels are quite evidently either glacial, or a reconcentrate of glacial material.

Panning in the sluice-boxes gave only fine gold, but in this connexion it is only fair to state that as the cut was merely started and bedrock above the head of the sluice still had considerable gravel and boulders on it, coarse gold was hardly to be expected in the sluices. The gold seen was flat or flaky, but minutely rough. The panning showed no black sand and only a little garnet.

The property is worked by pumping water from the creek to a small monitor.

A few hundred yards upstream a small cut had been made at the edge of the bench, exposing lower gravels similar to those seen in the lower cut.

Cedar Creek Placer Gold Mining Company, Limited

This company, in 1931, prospected the bench lying to the north of Cedar Creek, and on the results obtained by preliminary drilling secured a number of leases extending from the east of two small gullies known as Fisher and Beaver Creeks, nearly to the head of Cedar Creek. The prospecting by the company consisted of drilling a line of holes across the flat to the north of Cedar Creek Canyon. Forty holes in all were drilled at the time of the writer's visit to the property and it is reported that additional drilling was subsequently done. The drilling started from the Thom lease and extended across the Frost and A. C. Whiteside leases. These holes comprising the first line were drilled at intervals of 500 to 1,500 feet apart. Holes 1 to 14 showed depths ranging from 8 to 43 feet to bedrock; holes 15 and 16 did not reach bedrock; the former is 75 feet deep, indicating a deep gutter in the bedrock at that point. This bedrock depression is 2,500 feet wide. Holes 17 to 37 showed depths ranging from 15 to 25 feet, and holes 38 to 40 indicated another deep gutter in bedrock, lying on the A. C. Whiteside lease. The total width of this depression is not indicated by the drilling.

Gold values were reported by the engineer in charge of the drilling and the property was optioned by the United States Smelting and Refining Company, but preliminary testing by this company failed to substantiate these values and it is understood that the option was dropped. Test pits sunk in the vicinity of two of the holes were examined by the writer and showed ordinary stony boulder clay, with no gravel. The concentrates from the drill holes are reported to carry a considerable amount of iron pyrite, which assays showed to be auriferous.

The two bedrock depressions might reasonably be presumed to be the sites of former channels of Cedar Creek or tributaries draining to that creek, but it is reported that these were later drilled without obtaining pay. Gold has been found at other points along this bench, i.e. in the workings of M. Donohue farther southeast and along the edge of the bench at Fisher and Beaver Creeks. A channel of Cedar Creek might have been reasonably expected to cross the bench, but in view of the extensive drilling done this does not now seem likely.

Somewhat farther upstream than the ground drilled, M. Donohue has a lease lying between certain leases of the Cedar Creek Placer Gold Mining Company. This lease is situated on a bench near the head of the canyon, about opposite the Boe property, and is being worked under option. A small cut had been started using a splash dam from one of the sloughs that occur on the upper bench. Preliminary prospecting included the sinking of three pits up to a distance of 300 feet north of the workings and at a somewhat higher elevation, but according to information supplied the pits did not reach bedrock. Good values in gold are reported to have been encountered in this work.

The cut was run to pick up bedrock on a somewhat lower bench than the shafts. The lower part of the cut did not reach bedrock, but in the upper part of the cut a higher part of the rock, which is regarded by the lessees as the rim of the channel, was encountered, with the surface of the rock apparently sloping into the hill. The lowest part of the bedrock in the cut is deeply weathered, showing clay grading downward with partly decomposed fragments of the bedrock into less and less altered rock until finally the hard rock is reached. This is believed to represent possibly a residual soil, which was undisturbed by glaciation. Above this in the cut is a boulder clay about 8 feet thick resting on bedrock, which here is swept clear of any residual deposits. The boulders in this clay are mostly rounded, and are mostly foreign to the locality. The boulder clay in the lower part of the cut is believed to rest on the residual clay, but this could not be absolutely determined. The lower deposit may, of course, be a boulder clay with the weathered fragments of rock caught up in it, but the transition to the solid rock is difficult to understand in this event. Above the boulder clay and towards the head of the pit are stratified gravels, with strata of sand and clay and containing several rusty gravel streaks. These stratified gravels have an exposed thickness of 10 feet.

According to the information given by the lessees all the gold obtained has come from the upper stratified gravels, so far as they know none has been derived from the boulder clay. The gold is described as being rough and coarse, and lumpy even in the small pieces. Nuggets of $1 and over have been reported from the shafts sunk above. The concentrates from this deposit, as in the case of other deposits in the area, carry a considerable amount of iron pyrite.

Until the cut has progressed farther it is difficult to obtain a fair idea of the property. The stratified gravels are believed to be outwash gravels, but they may be interglacial.

Boe Property

This property lies on the high bench to the south of Cedar Creek and embraces the discovery made in 1921 already referred to. The early history of the property has already been briefly sketched. For further details the reader is referred to the reports of the British Columbia Minister of Mines.

No definite figures of the actual production from this ground are available. In the early years the production ran close to $100,000 a year, but in later years the production has declined considerably from that figure. Nearly $400,000 is accounted for by the incomplete figures published by the British Columbia Minister of Mines. For some years the figures are not given.

The discovery pit is about 900 feet above Quesnel Lake on the old erosion or upland surface, which here stands at approximately 3,200 feet elevation. Owing to the methods of mining and to the fact that the lower part of the deposit has been largely worked out no data on certain essential points could be secured from an inspection of the workings, and the writer consequently repeats Johnston's (6, 1922) description of this part of the workings.

"In the discovery draw only a small thickness of muck and broken and partly disintegrated bedrock overlie the solid bedrock, the gold occurring in the broken bedrock and in crevices in the solid bedrock. The gold is coarse and nuggety, and not greatly worn. Gold has been found at various places in the discovery draw for about 500 feet downstream from the head. It is mostly on or in the bedrock. In places there is an overburden of several feet of barren glacial drift, and where the boulder clay is tight on bedrock the gold is absent. Several test pits sunk in the lower part of the draw failed to reveal pay gravels, but a 13-foot shaft on the left bank just below Platt's cabin showed good values in gravels beneath or in the boulder clay. The gravels are apparently glacial outwash, or reworked ancient stream gravels, for they are only slightly weathered. . . . . The discovery draw ends abruptly about 800 feet above Platt's cabin at a low ridge of drift 20 feet high. Farther upstream, near the Platt Stevens line, a small marsh occurs, and here also gold has been found in test pits. On the Platt ground it occurs at intervals in a shallow draw in the drift deposits for a distance of about 400 feet. The overburden of glacial drift is to 10 feet deep and the pay gravels are 1 to 5 feet thick. . . . . The pay gravels are yellowish to red because of the presence in them of oxidized clay. They appear to be, in part at least, re-sorted, probably by glacial waters. Finer gold is found in the surface wash farther down the draw, and is probably the result of concentration from the drift by Recent streams. Gold has also been found in test pits in a continuation of the draw into the Sheridan ground. A series of small depressions or channels extends along the north side of the trail leading to the pond in which one branch of Cedar Creek heads. They occur along the slope of the southwest side of the broad, upper part of Cedar Valley and are thought by the prospectors to mark the continuation of the gold-bearing channel. This supposition is not universal, for it is evident from a study of the map that a broad channel extends southeast at about the same level as that of the known gold occurrences. Small prospects are said to have been obtained at one or two places along the supposed course of the channel above the Sheridan claim, but apparently the finds so far are not of much importance. It cannot be said, however, that the area has been thoroughly prospected.

Mining development and prospecting during the summer resulted in the discovery of a body of remarkably rich gravels on the left bank of Discovery draw about 600 feet above Platt's cabin. The pay gravels rest on bedrock and are overlain by 1 to 10 feet of barren glacial drift and muck. They are reddened by the presence of clay, derived probably from the weathering of fragments of the country rock included in the gravels. Most of the gravel is angular, but some worn pebbles occur. No glaciated stones were seen in the gravel. The bedrock is fairly smooth, but is soft and easily excavated. It is apparently not glaciated. The pay gravels average about 3 feet in thickness and were exposed in mining operations for a width of 25 feet. . . . . They trend northwest into the bank on the west side of the draw. The gold is well distributed through the gravel. In places little if any occurs on or in the bedrock. In other places it is found in cracks and crevices in the bedrock to a depth of 2 feet."

Since Johnston's description was written a pit has been excavated stretching from the Discovery draw in a southeasterly direction for approximately 1,500 feet and ranging from about 50 to 200 feet wide.

The writer examined the sides of the pit with extreme care for evidences of preglacial gravels, overlain by boulder clay, but came to the conclusion that no such gravels are exposed along the sides of the pit, nor at the working face. At the pit face on the Sheridan lease the bedrock was overlain by shattered country rock mixed with clay, overlain by boulder clay and gravels, the latter two being largely intermingled. Owing to sloughing at the sides of the pit and to the fact that bedrock in the pit is to some extent covered by tailings, sections could not be obtained for the length of the pit, but where seen the relations are similar to those outlined at the face. In some places the boulder clay is tight on bedrock, in others there is shattered country rock between. At some points in the pit there is a seam of peaty material underlying the surface, the seam being up to about 1 foot. In the boulder clay in places are streaks of roughly stratified gravel. The boulder clay includes rounded, subangular, and angular fragments and boulders, with a considerable percentage of these formed from rocks that are entirely foreign to the vicinity, and some of which must have been transported for many miles. The more important types of rock noted were aplite, granite porphyry, granite, granite-gneiss, schist, quartz, and quartzite. The boulder clay is so tightly cemented as to require shooting before it can be broken down by piping.

According to the information received, the distribution of the gold has been very irregular. The bulk of the gold occurs close to, on, or even in, bedrock, but rich patches have been found up in the boulder clay, some distance above bedrock. It is believed that these occur usually associated with gravel caught up in the boulder clay, but some who have worked in the Cedar Creek pit affirm that some rusty streaks occurring in the boulder clay consisted of decomposed iron-stained quartz which was exceptionally rich in gold. No such occurrences were noted by the writer. Rusty streaks were observed in the boulder clay, but these appeared to be due to oxidized streaks in the clay itself.

Near the lower end of the pit is what has been termed the Nugget Patch, where the ground was phenomenally rich. As an example of the richness of the ground Johnston (1922) states, "In the six days from October 25 to October 30, 697 ounces 10 pennyweights 16 grains were produced with three rockers." In the pit, to the north of the Nugget Patch, a barren spot occurs. This has been thoroughly prospected. To the north of the barren spot is a fairly wide run of fine gold, which apparently continues down discovery draw only a short distance. The direction of the pay-streak is a fairly straight line running about north 50 degrees west, and immediately below the Nugget Patch on the continuation of this line the pay cuts off, almost abruptly. The slope of the bedrock here increases as indicated by prospecting, and the work done in this direction has so far failed to disclose more than an occasional nugget or finer pieces of gold in boulder clay. The average grade of bedrock measured along the pay-streak is about 4 per cent, according to the information supplied by Mr. Otto Baer, superintendent. Mr. Baer also stated that shafts have been sunk all around the continuation of the pay-streak on the Sheridan lease, southeastward from the face of the pit, but that only occasional nuggets, usually with considerable quartz attached, are found in this section.

From a study of the results of the drilling done in 1927, which were made available to the writer, the pay-streak as shown is approximately 1,800 feet long and 250 to 400 feet wide.

The bedrock consists of volcanics and is somewhat smooth in its contour, but in most places is soft and deeply weathered. A considerable number of small quartz veinlets occur in the bedrock. Lay (8, 1931, page 93) states, "Work during the year afforded very striking proof of the local origin of the gold, which has been found to be present in the bedrock to a noteworthy extent, and moreover the richest portions of the bedrock are those in which occur small quartz veinlets, which are conceivably the roots of eroded veins."

Character of the Gold. The writer saw only a relatively small amount of the gold panned in the workings. The following description is, therefore taken from Johnston's (1922) report.

"The gold found in discovery draw and in the workings on the west side of the draw is coarse and nuggety and as a rule not greatly worn. The pieces average perhaps 2 or 3 cents in value, but nuggets up to 3¾ ounces have been found. The gold is mostly dark red, apparently due to a surface film or iron oxide. Many of the nuggets are irregular in shape; the protuberances are somewhat rounded or worn and the depressions frequently contain fragments of quartz embedded in the gold. Others are well worn. There is, therefore, no doubt that the gold is placer gold in the sense that it has suffered some transportation and wear after being released from the parent vein.

The gold found on the Platt ground is finer than on the discovery ground. The pieces average about six to the cent and are fairly uniform in size. Much of the gold is flattened and worn. The worn character and fairly uniform size indicate transportation and sorting by streams, at least to some extent."

Origin of the Deposit. The question of origin of the deposit has given rise to a wide divergence of opinion amongst engineers and others who have studied it. At the outset it must be stated that the evidence bearing on origin is highly conflicting. However, three main views have been published or expressed personally to the writer: (1) That the deposit is essentially a preglacial channel undisturbed, or only partly disturbed, by the ice. (2) That the deposit is preglacial, but that it is not in situ, that is to say it has been transported to its present position by ice. (3) That the deposit is residual or eluvial, disturbed by ice.

The first theory was put forward by Johnston (1922) who considered that the deposit was in place, but considered that it might have been transported. The chief objections that can be raised to this theory are the apparent lack of rims to the channel, the bedrock detritus described in places, and in places the lack of bedrock gravels, and the occurrence of gold up in the boulder clay. The deposit is apparently resting at random on what appears to be a normal erosion surface, sloping towards Quesnel Valley, and also towards Cedar Creek. No bedrock gutter is apparent that would confine the water to a channel. It might be argued that the deposit apparently lines up in elevation with the broad valley of Cedar Creek, and was formerly more extensive, but if this were the case, and a patch of the old channel were preserved at one point, one would expect to find other patches that had escaped removal by glacial erosion. So far these have not been found. The pay at the lower end cuts off almost abruptly below what was the richest part of the deposit. Below, towards Cedar Creek, there is apparently some gold, the concentration from glacial streams. The bedrock detritus existing in an old channel with a 4 per cent grade is somewhat difficult to explain. Although bedrock gravels could not be found by the writer, Johnston refers to them, but their presence at points does not necessarily signify that they are in place. The occurrence of gold at points well up in the boulder clay is a certain indication of disturbance by ice.

The second theory, namely, that the deposit has been transported almost bodily by ice, fails to account for the occurrence of the gold on or in the bedrock, nor does it account for the probable local origin of the gold and the relation of this to the veins in bedrock. It might perhaps be conceded that the bedrock concentrations were accomplished by water possibly issuing from the ice front, or flowing beneath the ice.

The third theory has some points in its favour. Eluvial deposits formed by the weathering of the rock and the gradual removal of the lighter or more easily soluble material would naturally be rich, particularly where this is combined with a process of secondary enrichment in the veins themselves. This theory would, however, fail to account to some extent for the concentration of the gold in bedrock and on it, and for the wear which Johnston notes in the gold. The bedrock gravels noted by Johnston would also be difficult to explain. That the deposit has been disturbed by glaciation cannot be doubted and concentration may have been affected by the water issuing from the ice front.

All told the evidence may be regarded as too conflicting to arrive at any very positive conclusion with regard to the origin of the deposit.

Beaver Creek

Only a relatively small part of Beaver Creek lies within the map-area. This part of the valley is moderately wide, and is bordered by benches of glacial deposits. The upper part of the valley, that is the part above the benches, is a broad, shallow depression. The tributary streams entering the valley do so through canyons cut either in rock or in unconsolidataed deposits, but good sections in this part of the area are rare. The stream cutting is not active, for a temporary base-level has been established, and Beaver Creek is a sluggish stream joining a number of lake expansions. To the north of Joan Lake a former bend of the river has apparently been cut off by a more recent cutting, but the age of this new cutting could not be definitely established. The abandoned bend is filled with glaciofluvial deposits.

So far as known, little prospecting has been done in this stretch of Beaver Valley. The depth to bedrock in the valley bottom is not known. Some shafts were observed in some of the tributary valleys, but the results of this prospecting could not be ascertained.

Old Channel Deposits

There is marked evidence of several old channel deposits in the area. The better known examples are Bullion Channel, Morehead Channel, the channel of the North Fork of Quesnel River and its tributary, Spanish Creek. Others are believed to exist.

The general features of these channels have been described in connexion with the individual properties. Morehead Channel occupies a valley that passes from near the Bullion mine, near the South Fork of Quesnel River, by way of Long Lake and Little Lake to Quesnel River at the mouth of Morehead Creek. It is believed to represent the old channel of the South Fork, when that stream stood at a much higher elevation than now, and drained by way of the present South Fork Valley from Quesnel Lake to the entrance of this valley near the Bullion mine. Practically all the information concerning this channel is that obtained from the Morehead pit near the lower end of its course. Over most of its length the depth to bedrock is not known, and consequently the grade and gold values are also unknown. It has been pointed out in the section dealing with the origin of the physical features that it cannot be definitely asserted that this valley is the old channel of the South Fork, but in any event it represents a valley of considerable size, and apparently cut before the Pleistocene. The grade of the bedrock as ascertained at the Morehead pit is 1·25 per cent. It seems probable that the grade along part of its course is flatter than this, for such a grade would carry the bedrock to the surface of the valley, which does not occur. This grade, or even a much flatter grade, would carry the bedrock far above the level of the bedrock of Bullion Channel; these two channels have very often been referred to as part of the same system, or as preglacial channels of the South Fork, but it is obvious that they cannot be part of the same channel, for the grade in both cases points to a flow in the same general direction, namely, from east to west. To assume that they are both preglacial would require the assumption that the South Fork had been captured by a small tributary of the North Fork. There is, however, some evidence that Bullion Channel is interglacial. Morehead Channel appears to receive a tributary from the upper part of Morehead Creek, where the occurrence of an old channel has been noted on Prior's property. It is also quite likely that it received a tributary from the direction of Polley Lake. The streams entering in the vicinity of Hydraulic, on the south side of the valley, have cut deep gorges in glacial materials, in contrast with the rock walls that appear farther east along the valley, and one of these streams occupies a valley that is practically continuous with the valley of Polley Lake. Other tributaries no doubt drained into this valley.

Morehead Channel has been proved to be gold-bearing at its lower end. There is no evidence to show whether this gold originally came from Morehead Creek, or whether gold may be expected for the length of the valley, but it is not unreasonable to assume that it is gold-bearing throughout its length.

Bullion Channel has been described in connexion with the Bullion mine. It is not known how far this channel parallels the South Fork, as it is supposed either to cross the South Fork or to coincide with the present course of that stream for part of the stretch between Bullion mine and Quesnel Lake, but the point where it enters the present channel could not be definitely ascertained. In Hobson's reports on the property this channel is reported to have a length of 1½ miles. No exposures of unconsolidated materials that could be certainly referred to this channel were found above the South Fork pit on Black Jack Gulch, though the channel is referred to as crossing the next gulch easterly.

On the North Fork of the Quesnel there is evidence of a channel, deeply buried and separated in places from that stream by a rim of rock. This channel is indicated on the south side of the river at intervals from near the mouth of Spanish Creek to the Burns leases, and probably extends to the Hepburn pit. It is uncertain whether it crosses the river at the Hepburn pit, but if so it is believed to recross and continue down on the south side of the river and across part of the Johnson (Cariboo and Seattle Company) ground. Where sluicing was done on this ground the channel bedrock appears to be below the water-level of the river, and to cross the river at this point. Below this its course is somewhat more uncertain. Tunnelling work undertaken by Westenhiser is believed to indicate that it lies on the north side of the river at this point. Between Murderer Gulch and the Bendtsen ground it is supposed to lie on the south side, and it seems probable that the deep ground near the mouth of Kangaroo Creek may be explained as lying over this channel. Below this its course is lost. A deep channel to correspond with this undoubtedly extends down Quesnel River from the forks, but no evidence can be obtained on which to base its location.

On Spanish Creek very good evidence of a deeply buried channel has been obtained (*See* Standard Mines). It is on this ground that the best evidence as to depth and gold content has been obtained. It is uncertain whether this is the continuation of the buried channel of the North Fork or merely a tributary to it, but the latter seems the more likely explanation. Drifting was done on the rim of this channel in the early days, and is reported to have yielded from 2 ounces to 17 ounces of gold to the set. The property was sold and equipped as an hydraulic mine, but the hydraulic operations carried out were entirely in the overburden.

The existence of the old, high-level valleys and their position in the former drainage have previously been referred to. In the case of these valleys there is very little evidence as to the chances for the discovery of commercial deposits of placer gold. It would be reasonable to infer that gold was concentrated in these valleys in the Tertiary, but the chance of such concentrations being destroyed by glacial erosion seems greater than in the case of the narrow and more deeply cut valleys. Most of these valleys cannot be said to be thoroughly prospected, probably on account of the thickness of the glacial accumulations in them, and also on account of the difficulty of sinking through some of these glacial materials. From these high-level valleys, however, there should be Tertiary courses connecting with the deeper channels such as the North Fork. In most cases there are few clues as to where these may be expected. Rock canyons in the lower reaches of these streams may indicate places of departure from the Tertiary courses, but this cannot be stated as a general rule. Drilling across the general valley depression of these streams would appear to offer the best way of finding such deposits. It is, of course, possible that the gold deposits worked by the early miners on these streams represented in part the preglacial concentrations, but it is believed that the gold deposits worked at that time were largely the post-glacial concentrations.

There is apparently no low level channel on the South Fork to correspond with that on the North Fork. This may be explained by the theory that the South Fork was apparently changing its channel, whereas the North Fork persisted in the same valley.

It is apparent, even to the casual observer, that in the old channels outlined there is an enormous yardage of gravel, running to many hundreds of millions of yards. The gravel content of Morehead and Bullion Channels alone has been estimated in the British Columbia Minister of Mines report (1902, page 61) at 500,000,000 yards. The gold content of these gravels is largely unknown, but at the points where they have been worked they have proved auriferous. If a gold content somewhat similar to the sections already worked, as for example the Bullion and Morehead mines, be postulated, it could readily be figured that these channels contain considerably more gold than has been produced from Cariboo District as a whole to date. Figures such as these are useful only in showing what might be expected. They cannot be classed as engineering estimates. It should be emphasized, however, that only a small fraction of this gold is economically recoverable under present methods of placer mining.

The gold contained in Bullion Channel is probably all commercially recoverable. Recent operations are reported to have shown an operating profit, and if the values shown in the past are maintained, there appears to be no reason why the property should not continue as a producer. The present water supply is, however, inadequate for the needs of the property.

Morehead Channel is more uncertain. The gold values are probably not so well known as in the case of the Bullion. The limiting factor in this channel is the grade of bedrock. The channel can be attacked from either end, but as the grade of bedrock is low, a sluice grade of 4 to 5 per cent will eventually pass above bedrock. When this condition obtains, the gravels would have to be elevated, which would require fairly rich ground. Other factors are, of course, the cost of maintaining a very lengthy sluice line, and the water available to work the property. In any event, the amount of this channel that can be worked by hydraulicking is definitely limited. Dredging is probably out of the question on account of the depth of the ground and the size of the boulders likely to be encountered.

North Fork Channel and Spanish Creek Channel have so many unknown factors that little can be said with regard to them. It is not improbable, however, that stretches of the bedrock may lie below the water-level of the North Fork, so that hydraulicking, other than as a means of stripping, may be out of the question. If the bedrock of the channel lies below the available dump, the lower gravels would require to be elevated. This would depend very largely on the gold content. Dredging might also prove impractical on account of the boulders.

It will be seen, therefore, that although the gold content of these channels is probably, in the aggregate, quite large, serious difficulties lie in the way of its commercial recovery. There is in each case a lack of information necessary to permit it being considered from an engineering standpoint. Such information could only be secured by drilling.

QUARTZ VEINS

Quartz veins were noted at some points within the area and at points lying immediately to the east of the eastern border of the area. There is a strong assumption that a belt of quartz veins crosses the northeast corner, or the area from the vicinity of Kangaroo Creek towards Cedar Creek and Quesnel Lake, but owing to the heavy overburden that obscures bedrock in most places only a very fragmentary account can be given. It is believed, however, that veins and stringers of quartz are relatively numerous in this part of the area, and there is an indication that the placer gold owes its origin to them, as the main deposits occur somewhat to the southwest of the belt of veins, and placer gold is not known to occur on the creeks above the belt of veins.

KANGAROO CREEK

A vein of considerable size was noted on a tributary joining Kangaroo Creek from the east about 1½ miles above the mouth of Kangaroo Creek. The vein occurs on the northern side of the tributary, about 900 feet from its mouth, and was flat-lying, cutting greenstone. The vein, 6 feet wide, was a banded quartz and calcite vein, containing no visible sulphide. Beyond a trace of copper stain the vein was apparently barren.

TWOMILE CREEK

On the first tributary to the North Fork of Quesnel River, entering from the north above Kangaroo Creek, locally known as Twomile Creek, there is a canyon cut in greenstone about 250 yards above the old Quesnel Forks-Keithley road. The greenstone contains numerous stringers of calcite. About 400 yards above the road there is a waterfall and here several veins of calcite, striking east and west, and dipping vertically, with a width of 6 inches, cross the canyon. The calcite is stained a rusty brown, and in places contains fairly massive mineralization of iron and copper sulphides.

NORTH FORK OF QUESNEL RIVER

A number of veins were noted on North Fork of Quesnel River between Wolverine Creek and the mouth of Spanish Creek. On the south side of the river at the Johnson (Cariboo and Seattle Company) ground the argillite is cut by numerous veinlets of quartz. Cubes of pyrite are abundant in the argillite adjoining the veins.

On the Burns leases in the vicinity of the upper cut the argillites are again cut by numerous stringers of quartz. One main vein of rusty brown quartz, several feet wide and striking with the formation, was noted, but no sulphides were observed in it.

On the property of the Ruby Creek Mines, Limited, below the upper tunnel, are two quartz veins 14 and 24 inches wide, striking with the formation and dipping steeply into the hillside. No sulphides were observed.

On the north bank of the river, a short distance above the mouth of Dry Gulch, the argillites contain numerous kidneys of quartz and one quartz vein, about 6 feet wide, badly disturbed, but which appeared to strike and dip across the formation. The quartz is very largely barren of sulphides, but specks of galena were noted in places.

The following notes are taken from Bowman's (1) report:

Moore's Ledge

This ledge is reported to be outcropping at low water on the left bank of the North Fork about 100 yards above the mouth of Spanish Creek. The ledge is 3 feet wide and strikes across the river.

Ne Tye Ledge

Exposed by Chinese hydraulicking about a mile below the mouth of Spanish Creek. The strike is northwest, dip northeast, about 60 degrees. Enclosing slates strike east and west and dip north at 8 degrees. The body is 1 to 4 feet, irregular in continuation with quartz, limonite (?) from decomposed pyrite. Assay gave: gold, trace; silver, none.

Diller Tunnel

This tunnel was run into a point on the right bank intersecting a ledge in this vicinity.

Stephenson Ledge

This ledge is also on the right bank $1\frac{3}{4}$ miles below the mouth of Spanish Creek, and was opened by a shaft and tunnel in 1878. Body and contents unknown.

SPANISH CREEK

Bowman reports seven or eight ledges on Spanish Creek. About a mile above the mouth there is a ledge 2 feet wide, not containing any sulphides. There is a ledge 5 to 7 feet wide near the mouth of Black Bear Creek. It contains galena in streaks about an inch wide and strikes north-northeast. The other ledges are described as lying on Black Bear Creek, which is a considerable distance from the edge of the area.

DUCK CREEK

On Duck Creek a short distance above the Keithley road, and some distance east of the map-area, a number of ledges are being prospected by W. Bleuveldt. These vary from seams of quartz to veins up to 2 or 3 feet wide. Seven small quartz veins were seen in a distance of 500 feet in the creek bed. The veins strike generally northeast and dip to the south-cast at angles from 42 to 60 degrees. The mineralization is generally sparse, consisting of galena, pyrite, chalcopyrite, and zinc blende. Only locally is the impregnation of sulphides heavy. On several of the veins the wall-rock is apparently an altered intrusive carrying mariposite. Assays by Lay (1926, page 178) from picked samples showed: gold, 0·02 ounce; silver, 24 ounces; lead, 42 per cent; zinc, 6 per cent.

CEDAR CREEK

On Cedar Creek are a number of shear zones, described by Galloway (10, 1923, page 131), varying in width from 1 to 8 feet and having a strike of south 60 degrees east, with a fairly flat dip to the northeast. These cut the andesite of the canyon about a mile from the mouth. The mineralization is irregular; there is little or no quartz. The metallic minerals are pyrrhotite, pyrite, arsenopyrite, galena, and chalcopyrite. Assays by Galloway showed considerable values in gold.

SOUTH FORK OF QUESNEL RIVER

On the South Fork of Quesnel River, in the bedrock cut of the South Fork pit of the Bullion mine, are a number of zones cutting the diabase. These are stained a deep red, owing to the oxidation of the iron they contain. Arsenopyrite was found disseminated in the rock in these zones. At the mouth of the bedrock cut are argillites and greenstones with numbers of fractures filled with seams of calcite.

BIBLIOGRAPHY

1. Bowman, A.: Geol. Surv., Canada, Ann. Rept., vol. III, 1887-8.
2. Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1931.
3. Dawson, G. M.: Geol. Surv., Canada, Ann. Rept., vol. III, 1887-8; vol. VII, 1894.
4. Dolmage, V.: B. C. Miner, May, 1932.
5. Galloway, J. D.: *See* Reports of B.C. Minister of Mines.
6. Johnston, W. A.: Geol. Surv., Canada, Sum. Rept. 1922.
7. Johnston, W. A., and Uglow, W. L.: Geol. Surv., Canada, Mem. 149, "Placer and Vein Gold Deposits of Barkerville", 1926.
8. Lay, D.: Reports of B.C. Minister of Mines.
9. Reinecke, L.: Geol. Surv., Canada, Mem. 118, "Mineral Deposits between Lillooet and Prince George", 1920.
10. Reports of B.C. Minister of Mines.
11. Uglow, W. L.: Geol. Surv., Canada, Sum. Rept. 1921.
12. Walker, J. F.: Geol. Surv., Canada, Sum. Rept. 1930.

INDEX

The annual Summary Report of the Geological Survey is issued in parts, referring to particular subjects or districts. This year there are five parts, A I, A II, 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.