Arthur H Lang

CANADA

DEPARTMENT OF MINES

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

GEOLOGICAL SURVEY

W. H. COLLINS, DIRECTOR

MEMOIR 149

No. 130, GEOLOGICAL SERIES

Placer and Vein Gold Deposits of Barkerville, Cariboo District, British Columbia

BY

W. A. Johnston and W. L. Uglow

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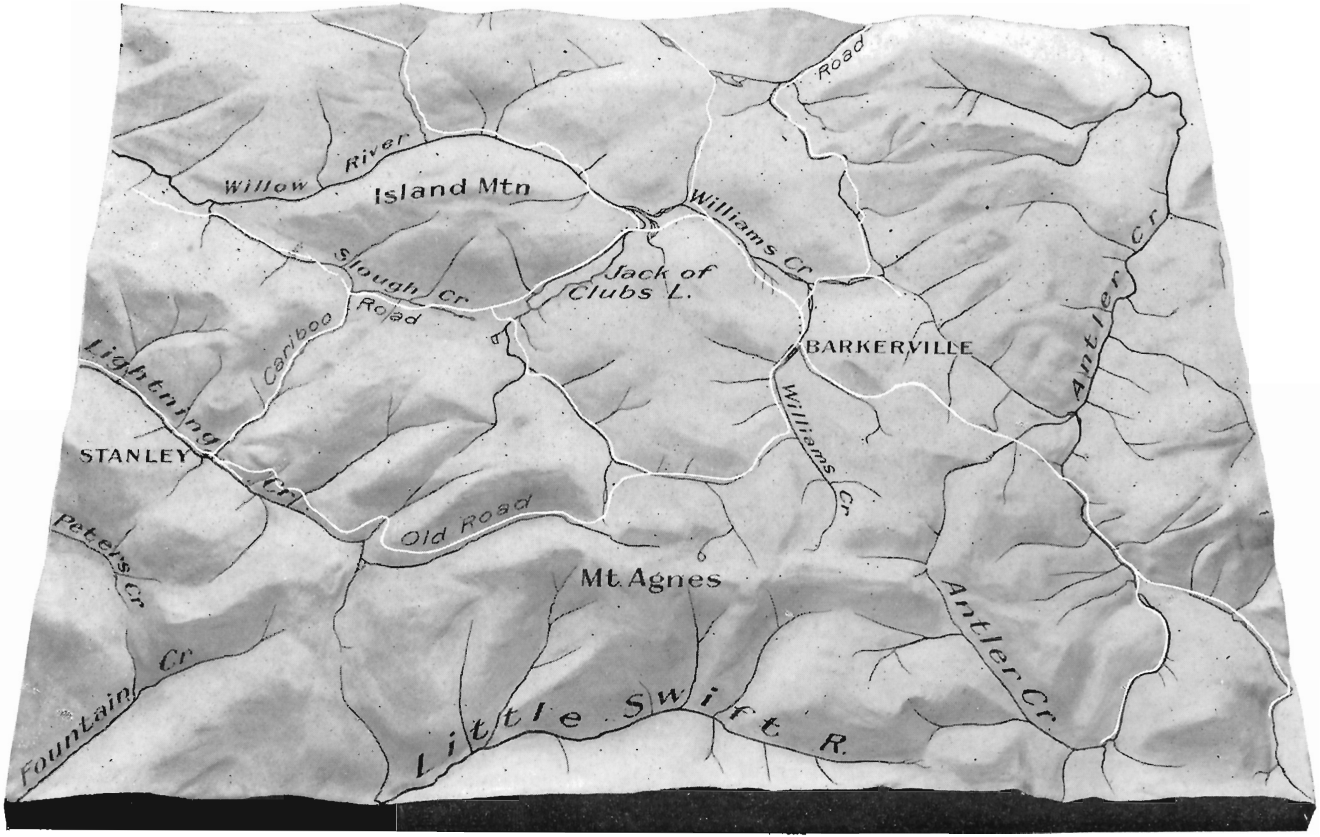

Photograph of relief model of Barkerville area. (Page 2.)

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CHAPTER I

INTRODUCTION

Barkerville area embraces 210 square miles and is part of Cariboo district, central British Columbia. The town of Barkerville, the centre of the area, is about 60 miles east of Quesnel, on Fraser river, in latitude 53° north. The placer mines of this area have produced, since 1860, about $30,000,000 in gold, and although the greater part of the yield was obtained in the sixties and seventies, varying amounts of gold have been produced annually since then. The main producing creeks of Cariboo district—Williams, Lightning, and Antler—are included in Barkerville area. In the early days of placer mining the rich, readily accessible pay-streaks in the beds of the creeks were mined out, partly by open-cut work and partly by drifting. Hydraulicking began in the seventies and has been carried on at some of the properties for over forty years. The area has been glaciated and in many places thick deposits of drift overlie the pay-streaks. As a result, not only has mining been difficult, but the finding of deposits was so delayed that fresh discoveries have been made periodically since the early days, and it is possible that still further finds will be made. In recent years attention has been specially directed to the possibilities of gold-dredging—which was actually started in 1924—and the mining of the quartz veins from which the placer gold was derived.

The area was geologically examined by the authors for the purpose of determining the source of the placer gold and of describing the possibilities for placer and "quartz" mining. The senior author (W. A. Johnston) is responsible for the descriptions of the superficial deposits and of the placer mining operations on the several creeks. The junior author (W. L. Uglow) is responsible for the descriptions of the bedrock geology and of the quartz vein deposits. The authors are jointly responsible for the chapter on the origin of the placer gold, and for the section on the origin of the physical features.

ACCESSIBILITY

Barkerville area may be easily reached by stage from either Ashcroft or Quesnel, the route to Quesnel being by boat from Vancouver to Squamish and thence by Pacific Great Eastern railway, or—in summer—by gas boat from Prince George. From Barkerville good roads extend to Bowron (Bear) lake and to Grouse, Antler, and Cunningham creeks. Other roads and trails lead to most of the creeks in the area. The old road to Barkerville, constructed in 1865, formerly extended past Stanley to the head of Lightning creek, crossed a divide to Jack of Clubs creek, followed this creek a short distance, and by another low divide reached Williams creek which it followed down to Richfield and Barkerville. The route was changed in 1885 and is now through Devil canyon above Stanley and along Slough Creek valley and past Jack of Clubs lake to Williams creek. The old road in the upper part of Lightning Creek valley is impassable except on foot. A pack trail connects Barkerville with Keithley at the mouth of Keithley creek, 30 miles to the southeast. Travelling in the area, especially in the higher parts, is comparatively easy and although the valley bottoms and sides are mostly wooded and many of the old trails overgrown by vegetation, pack horses can be taken nearly everywhere.

GENERAL CHARACTER OF DISTRICT

The plateau region of British Columbia, of which the Barkerville area is a part, occupies an intermontane belt, bounded by the Coast range on the west, and by the Cariboo and other mountain ranges on the east. The region is characterized by relatively flat-topped, inter-valley ridges, whose summit levels maintain a general accordance within the smaller units of area, but over larger areas show a gradual change from 6,500 down to about 3,500 feet. The valley bottoms range in elevation from several hundred to more than 4,500 feet above sea-level, and subdivide the uplands into many series of irregular-shaped blocks.

The part of the belt of Interior Plateaux contained within the Barkerville map-area consists of an uplifted, highly dissected, plain-like surface of erosion in which summit levels vary from 5,500 to 6,600 feet above sea-level (*See* Plates I, II, and III). In the eastern part of the area, the mountains rise to 6,500 feet, whereas along the western margin, in the vicinity of Stanley, the summit levels do not exceed 5,500 feet. There is, consequently, a general slope of the upland surface in a westerly or southwesterly direction of approximately 75 feet per mile.

The relief on the upland surfaces is slight. Many of the plateau remnants, almost entirely surrounded by deep valleys, show a striking flatness characteristic of base-levelled country. Bald Mountain plateau, for example, is remarkably flat and exhibits only minor irregularities of surface. The upper parts of it are devoid of timber and are covered only by thick meadow grass and a profusion of wild flowering plants. It is in exceedingly marked topographic contrast with the serrated character of the Cariboo range to the east. Here and there small residual eminences or monadnocks rise above the general level of the uplands to heights of 300 feet, constituting the only survivals of the mountains that existed in the early part of the previous geographic cycle. Mount Agnes (6,500 feet), mount Burdett (6,600 feet), and Two Sisters mountain (6,700 feet), are the most striking illustrations of these monadnocks.

The topographic unconformities between the old plain-like surfaces above and the newer valley topography below are usually sharply defined and abrupt on the northern boundaries of the uplands. This abruptness is due to the presence of many cirques, the headward slopes of which meet the plateau tops with almost knife-edge boundaries. On the southern parts of the uplands; the topographic breaks are not nearly so well defined.

The slopes of the old and new land forms merge somewhat gradually and the unconformity can best be observed in a distant view.

Most of the important gold-bearing streams, including Antler, Grouse, Williams, and Lightning creeks, radiate from the Bald Mountain plateau which was known in the early days as "The Bald Mountain of Williams creek," and was so called because it is largely above timber-line. Tyrrell[1] has drawn attention to the fact that there is a certain similarity between this upland and the Dome at the head of Bonanza creek in the Klondike. The upland has an average level of about 6,200 feet and from it the creeks descend rapidly, so that within a distance of from 5 to 10 miles from their sources they flow in valleys whose bottoms in places are over 2,000 feet below the plateau level. The valleys are narrow and steep-sided in the upper parts, but locally have the U-shaped cross-section characteristic of glacially eroded valleys. They broaden out in the lower parts, where they are deeply drift-filled and have alluvial flats with a general elevation of about 4,000 feet above sea.

The streams of the area show a markedly irregular pattern owing to the deep dissection and various controlling factors that were operative during the period of formation. The main drainage is to the northeast by Willow river which occupies a broad, deeply drift-filled valley. The drainage of the eastern part is to the north by Antler creek, following a broad valley in the bottom of which is a newer rock canyon. Below Russian creek this canyon is very narrow and about 100 feet deep. Narrow rock canyons also occur on Antler creek above the mouth of Grouse creek and in the upper part of the valley. There is thus evidence of comparatively recent local deepening of Antler Creek valley in contrast with the drift-filled valleys in the western part of the area. Many of the creeks throughout the area have in places small rock canyons along the side of which are the older drift-filled channels of the streams.

Jack of Clubs lake is the largest lake in the area and has a maximum depth of about 175 feet. There are several smaller lakes, all of which occur in the valley bottoms. They are due to irregularities in the drift filling of the valleys or, possibly, as in the case of Groundhog lake and perhaps one or two others, to the existence of rock basins.

The uplands and higher summits are grass lands or moors over which travelling is easy, but elsewhere the area is well wooded and an abundance of timber, chiefly spruce and balsam fir, averaging about 1 foot in diameter, is available. The common trees, approximately in the order of their abundance, are white spruce (*Picea canadensis*), black spruce (*Picea mariana*), aspen poplar (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), white birch (*Betula alba*), lodgepole pine (*Pinus murrayana*), western cedar (*Thuya plicata*), and alder and willow. Timber-line is at 6,200 feet. Above this level rock exposures are abundant, but below it bedrock is largely concealed. Below the 5,500 foot level underbrush is usually so thick as to make traversing difficult.

[1]Econ. Geol., vol. XIV, pp. 339 (1919).

PREVIOUS WORK

Parts of Cariboo district were examined geologically by G. M. Dawson in 1876 and 1894. The results of his work and summaries of the history of placer mining in the region are given in the Report of Progress, Geological Survey, Canada, 1876-77; in the Annual Report for 1887-88, part II, and in the Summary Report, 1894. The first systematic investigation of the rocks, veins, and placers was by Amos Bowman in 1885-86. The first part of Bowman's report, dealing chiefly with the general geology and the possibilities of lode mining in the district, was published in the Annual Report, Geological Survey, Canada, 1887-88. The second part, in which it was intended that detailed descriptions of the principal auriferous creeks should be given, was not published. A number of detailed maps of the creeks were prepared by Mr. Bowman, but in June, 1894, he died without having written any descriptive matter to accompany them. The maps, however, were published in 1895 by the Geological Survey with an explanatory note by G. M. Dawson. The question of the origin of the placer gold was discussed by A. J. R. Atkin[1] and has been incidentally referred to by several other writers who have examined parts of the district. W. Fleet Robertson made an exhaustive study of the veins and placers in 1902.[2] In 1918, B. R. MacKay[3] began an investigation of Cariboo district and continued the investigation during the succeeding year. In 1920, a topographical map of Barkerville area, No. 1961, scale one mile to the inch, was made by D. A. Nichols, Topographical Division, Geological Survey. Much of the available information regarding mining operations in the district is contained in the Gold Commissioners' reports, and in the more recent reports of J. D. Galloway.[4]

HISTORY OF EARLY MINING

The history of mining in the district prior to 1878 is given in considerable detail by Bancroft[5] and also by F. W. Howay and E. O. S. Scholefield.[6] Interesting data on the subject are to be found in numerous other publications and manuscripts which, including the early reports of the Gold Commissioners, are available for reference in the excellent Parliamentary library at Victoria, B.C. A few rare volumes and manuscripts on Cariboo are available for reference in the Public Archives at Ottawa. These old reports, as well as the later reports and Bowman's maps, are of interest and importance because they furnish the main evidence as to which creeks were thoroughly tested in the early days of mining, a question which has arisen many times in the past, and will doubtless arise in the future because of the peculiar condition existing in Cariboo—the presence of glacial drift overlying the gold-bearing gravels.

The following account of the events which led to the discovery of placer gold in Cariboo, and of the mining work done during the first few

[1] "The Genesis of the Gold Deposits of Barkerville (British Columbia) and the Vicinity"; Jour. Lond. Geol. Soc., vol. 60, pp. 389-393 (1904).
[2] Ann. Rept. Minister of Mines, B.C., 1902.
[3] Geol. Surv., Canada, Sum. Repts. 1918, 1919, pt. B.
[4] Ann. Rept., Minister of Mines, B.C.
[5] Bancroft, H.H.: "History of British Columbia" (1887).
[6] "British Columbia from the Earliest Days to the Present" (1914).

years is by G. M. Dawson[1] and is perhaps the most comprehensive that has been published. "It is now difficult to ascertain under what precise circumstances the first discovery of gold placers on the mainland of British Columbia occurred. Little attention was at first given to accounts of the finding of small quantities of gold, and at a later date, when gold mining sprung into importance, numerous stories respecting its discovery were invented or exhumed. One statement is to the effect that the Hudson's Bay agent at Kamloops had bought gold from the Indians as early as 1852, but if correct, the amount purchased must have been very small. In 1855, a servant of the same company discovered gold near Fort Colville, a short distance south of the International Boundary, and moderately rich diggings began to be worked in that vicinity. It seems certain that the epoch-making discovery of gold in British Columbia was the direct result of the Colville excitement. Indians from Thompson river, visiting a woman of their tribe who was married to a French Canadian at Walla-Walla, spread the report that gold, like that found at Colville, occurred also in their country, and in the summer or autumn of 1857 four or five Canadians and half-breeds crossed over to Thompson river, and succeeded in finding workable placers at Nicoamen, on that river, 9 miles above its mouth. On the return of these prospectors the news of the discovery of gold spread rapidly. It is also probable that their arrival on the Thompson caused the Indians to take an interest in gold mining, for we read in a despatch of Governor Sir James Douglas, that from October 6, 1857, to the end of that year, 300 ounces of gold had passed through the hands of the Hudson's Bay Company, this amount being all, so far as known to Douglas, which had been obtained. Douglas speaks of the region, including the lower Thompson from which the gold came, as the 'Couteau country.'

"Nearly ten years previously, in 1849, gold had been discovered in California, and that country was swarming with a cosmopolitan population of gold-seekers; thus when the discovery of gold in the north became known and authenticated, by the exhibition of the gold itself, an extraordinary migration followed. Between March and June, 1858, from 20,000 to 23,000 persons arrived by sea from San Francisco in Victoria, and converted that place (first founded by the Hudson's Bay Company in 1843) from a quiet village of two or three hundred inhabitants, into a city of tents. At the same time, many miners (estimated by some at eight thousand in number) reached British Columbia by overland routes from the south. A large proportion of those who arrived at Victoria never got as far as the mouth of Fraser river, their objective point, and so great were the natural difficulties and the resulting disappointment experienced, that all except about three thousand of this promiscuous migration returned to California before the following January. The inland country was entirely without routes of communication, by nature a singularly difficult one, and unprovided with means for the support of a large population. Meanwhile, by the more fortunate and energetic the development of its wealth had been fairly inaugurated. The auriferous river-bars in the vicinity of Hope and Yale on the lower Fraser, being the most accessible,

[1]"Mineral Wealth of British Columbia"; Geol. Surv., Canada, Ann. Rept., vol. III (pt. II), pt. R, pp. 18–21 (1889).

were the first to be worked, and the return of gold began to assume important dimensions.

"Before the close of the working season in 1858, some of the adventurers who had come overland from the south had pushed onward in face of extraordinary difficulties—resulting not alone from the roughness of the country itself but combined with the want of supplies and occasional overt hostility of the Indians—as far as Fountain, a short distance above Lillooet on the Fraser, and by the line of the Thompson to Tranquille river on Kamloops lake. In the following year a renewed advance brought a number of miners to Quesnel river, and in 1860 rich diggings were found at the forks of the river and over 600 whites were at work on its length, while Antler creek was discovered and some work done upon it by a few score men—thus fairly entered on the extremely rich central region of Cariboo.

"The theory formed by the miners who first worked the fine 'flour' gold of the Fraser below Yale was that this gold had its origin in richer deposits toward the sources of the great river, and though this theory was only partly correct as regards the origin of these particular deposits, it none the less served as the impelling force which led to the opening up of Cariboo district.

"In 1861, Williams and Lightning creeks, Cariboo, the two most celebrated in the annals of British Columbia placer-mining, were discovered, and in this and the following year most of the other rich creeks in Cariboo became known. The first gleanings from the old Cariboo stream-courses were notable. It is estimated that gold to the value of $2,000,000 had been got out by a population not exceeding fifteen hundred before the end of 1861. In consequence of those finds a second important migration of miners and others towards the province commenced before the close of 1861, which continued in greater or less volume until about 1864. A series of letters from a correspondent of the 'Times' contributed largely to this result, and extended the area of interest to very wide limits, bringing adventurers from England, Canada, Australia, and New Zealand. A party of men even set out for Cariboo from eastern Canada overland, in 1862. Of this party several members lost their lives in the mountains, but some eventually reached their destination."

An interesting account of the "rush" up the Fraser in 1858 is given by Kinahan Cornwallis in his book "The New Eldorado, or British Columbia," published in 1858. The book is accompanied by a remarkable map on which the words "Supposed gold regions" are printed nearly all over that part of Cariboo region where the really important discoveries were made two years later. This illustrated the belief of the prospectors that the trail of fine gold on Fraser and Thompson rivers would lead to rich deposits of coarse gold in the mountains near the headwaters of the stream. The theory of the miners, as pointed out by Dawson, was only partly correct, for the greater part of the gold on the Fraser was derived by concentration due to stream erosion of the glacial drift, and a part was locally derived. A considerable part, however, may have originally come from Cariboo region, in pre-Glacial time, or have been transported in the glacial drift from that region. The trail of fine gold was not followed directly to the area, but up the north fork of Quesnel river, where the trail was lost below Cariboo lake. From there the search was extended over the divide to Antler, Williams, Lightning, and other creeks in Barkerville area. The theory was more or less sound in respect to Keithley, Harvey, and Cunningham creeks in Quesnel River basin southeast of Barkerville.

The total placer gold production of Cariboo is not definitely known. In the estimates[1] of early gold production an amount equal to one-third of the amount actually known to have been exported by banks, etc., was added to represent the gold carried away in private hands. From 1878 to 1894 inclusive one-fifth was added. The gold production from Cariboo from 1874 to 1923 inclusive, as given in the Annual Reports of the Minister of Mines, B.C., is $16,896,376. The total gold production of the province from 1861 to 1873 inclusive, is given as $32,817,680. The greater part of this, possibly $28,000,000, came from Cariboo and a small part from Omineca and Similkameen. The total gold production of Cariboo, therefore, may be about $45,000,000. Of this amount Quesnel district has produced since 1874 about $5,500,000 and a fairly large amount was produced in this district prior to 1874. The production from Barkerville district may, therefore, be $35,000,000, or somewhat more. This estimate is much smaller than that of old-timers in the region, who hold that the amounts allowed for gold carried away in private hands should have been much larger. They believe, for example, that the production of Williams and Lightning creeks alone was over $30,000,000. It would seem, however, that the early Gold Commissioners, who gave the estimates of gold production, were best able to judge as to the actual amounts. In the Annual Report of the Minister of Mines, B.C., for 1896, the total gold production of Williams creek and its tributaries is given as $19,320,000. Accepting this estimate—which, it should be remembered, was made long after most of the mining was done, and is likely to be an exaggeration—the creek produced about $1,000 to the running foot of valley. The statement has frequently been made that Williams creek was the richest placer creek ever discovered. The gold production of Bonanza and especially Eldorado creeks in the Klondike was much greater than $1,000 a running foot of valley.[2] These creeks were, therefore, richer than Williams creek. The largest gold production from Cariboo was in 1863, when it produced the greater part of the provincial total of $3,913,563. After 1863 the production from Cariboo gradually declined, but as late as 1915 the area produced $300,000, chiefly because of the extensive hydraulic operations by John Hopp. For several years following 1915 the annual production was only $60,000 to $80,000, but during the past three years it has been increased to about $200,000 by the gold output from Cedar creek in Quesnel Lake district. It is probable that the gold output from Barkerville district will be materially increased by the dredging operations now being undertaken.

[1]Dawson, G.M.: ibid, pt. R. p. 23.

[2]McConnell, R. G.: "Report on the Klondike Gold Fields"; Geol. Surv., Canada, Ann. Rept., vol. XV, pt. B, p. 41.

ACKNOWLEDGMENTS

Field work was done by the senior author (W. A. Johnston) in Barkerville district and in other parts of Cariboo during about two months in 1921 and during the field seasons of 1922 and 1923. A few weeks were also spent in Cariboo in the autumn of 1924. He was ably assisted in 1921 by Clive Miller, in 1922 by J. A. Maguire, and in 1923 by G. C. Lipsey and H. V. Warren. Field work was done by the junior author (W. L. Uglow) during three and one-half months in 1922. He was ably and loyally assisted by C. O. Swanson—who, during the latter part of the season, had charge of the areal mapping—and by G. C. Lipsey.

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CHAPTER II

GENERAL GEOLOGY

The accompanying table of formations and the geological map of Barkerville area (No. 2046) show the nature and distribution of the rocks. The consolidated 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 exterpolate 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	

Table of Formations—Continued

Period		Formation		Lithology	Thickness feet
			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
			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+

PRECAMBRIAN (?)

CARIBOO SERIES

Distribution

This series underlies about 85 per cent of the Barkerville map-area and extends continuously from the southwest corner to a line running along the western slopes of Slide mountain, and mounts Murray, Greenberry, Waverly, Howley, and Guyet. It is the series underlying the main part of the placer deposits, and placer gold has not been recovered to any extent outside of its boundaries. The Cariboo series was mapped by Bowman[1] 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.

Age and Correlation

The only available information regarding the age of the series is that 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. The much greater metamorphism of the Cariboo series, pointing to a period considerably antedating the Mississippian, as well as the lithological similarity of the members of the Cariboo series with the Beltian rocks, suggests that the Cariboo series is possibly of Beltian age. In making this tentative suggestion, the writer is aware of the gap of about 500 miles between this area and that of the recognized Beltian series, and of the danger of attempting to correlate groups of rocks located, as these two series are, on opposite sides of the Beltian axis. It might also be pointed out that the Barriere series[2] on North Thompson river and the Niskonlith series[3] between North Thompson river and Adams lake possess a lithology and structure similar to both the Cariboo series and the Beltian rocks.[4]

Richfield Formation

Distribution. This is the lowest formation recognized in the Cariboo series of Barkerville area. It underlies more than half of the western and southwestern parts of the map-area, and is bounded on the northeast by the limestone of the Barkerville formation. Its breadth is due partly to the topography, but largely to the fact that it is exposed along both limbs and the crest of a broad, open anticline, whose axis traverses the area in a northwesterly direction. The formation takes its name from the excellent series of exposures in Williams creek between Barkerville and Richfield.

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.

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[1]Bowman, A.: "Report on the Geology of the Mining District of Cariboo, British Columbia"; Geol. Surv., Canada, Ann. Rept., vol. III (pt. I), pt. C. (1889).
[2]Uglow, W. L.: "Geology of the North Thompson Valley Map-area"; Geol. Surv., Canada, Sum. Rept. 1921, pt. A, p. 72.
[3]Dawson, G. M.; "Report on the Area of the Kamloops Map-sheet, B.C."; Geol. Surv., Canada, Ann. Rept., vol. VII (1896).
[4]Schofield, S. J.: "Geology of the Cranbrook Map-area, B.C."; Geol. Surv., Canada, Mem. 76 (1915).

Lithology. The Richfield formation constitutes the main part of what is popularly known as the Cariboo schists, but strangely enough, true schists form only a small element in the series. 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 constitutes one of the striking members of this formation. 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. An attempt was made to outline this member on the map so as to elucidate the structure of the Richfield formation, but the attempt failed because of the lack of continuous exposures. It seems to be confined to one of the lowest exposed parts of the formation, and is believed to constitute one of the most competent strata controlling the regional deformation of the area.

Grading into the massive, thickly bedded 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, and the bedding planes are characterized by a parallel arrangement of sericite flakes. Within the confines of 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 prevalence of the faint brown colour seems to be due to the hematite or limonite cement of the sandstone from which the quartzite was derived. Excellent exposures of this member occur on mount Agnes and mount Burdett, as well as in the canyons of Williams and Antler creeks, above mentioned.

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 in character 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 in colour and very platy in structure. 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 this formation.

Barkerville Formation

Distribution. The rocks of this formation are exposed in two belts trending northwesterly across the eastern part of the area and coalescing on the western slope of mount Guyet. For the most part the 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 which 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.

Lithology. The chief rocks of this formation are limestones presenting characteristics which vary according to the intensity of their deformation. Typical exposures, as stated above, occur on the ridge extending southerly from Waverly mountain; the rocks are a thickly bedded, 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 (*See* Plate X). In many places, also, the rock is of autoclastic character, and 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 the folding of the rock series 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.

No trace of fossils was found in the limestone, although considerable time was spent in the search. The more massive varieties of the rock are relatively unmetamorphosed, and if fossils had been present they would probably have been well preserved. Extensive ridges of similar limestone

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

occur along the east side of Spectacle lake, and along Swamp river, to the east of the map boundary, and a search for fossils in these localities was also without result. Even the shaly partings appeared to be unfossiliferous.

Pleasant Valley Formation

Distribution. These rocks conformably overlie those of the Barkerville formation, and, like it, occur in two narrow belts trending northwesterly across the eastern part of the area. 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.

Lithology. The members of this formation are essentially argillaceous, the dominant type being a clay slate, varying in colour from grey to pale brown to black, and possessing a well-developed cleavage. Other rock types occurring in this formation are:

Calcareous slate, in which beds of argillaceous material, a fraction of an inch thick, alternate with thin beds of limestone
Phyllite, grey, brown, purplish
Knotted sericite schist, slate, and phyllite, in which the knots are cordierite
Chlorite schist
Quartz slate, greyish to brownish
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, with a greyish matric containing grains of quartz, elongated or angular fragments of blackish limestone, and of a rock resembling quartz porphyry
Black, knotted, glistening, pencil-like schist
Silver-white, knotted sericite schist
Limestone, fine-grained, grey-blue, slaty
Thinly bedded quartzite, sericitic

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

Distribution. A large number of brownish weathering sills and a few dykes occur cutting 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. For these two reasons, the locations of 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.

The formation is given its name from the occurrence of a quartz porphyry intrusive on the Kitchener mineral claim on Proserpine mountain.

Lithology. All the acidic sills and dykes which cut the Cariboo series have been grouped as the Proserpine intrusives. The examination of thin sections from exposures in several parts of the area shows that there is a variety of petrographical types, but owing to limited exposures and the alteration of the rocks it was found inadvisable to attempt to classify them more closely.

Quartz porphyry, felsite, aplite, and quartz latite are prevalent types. Their outcrops are characteristically iron-stained, due to the oxidation of

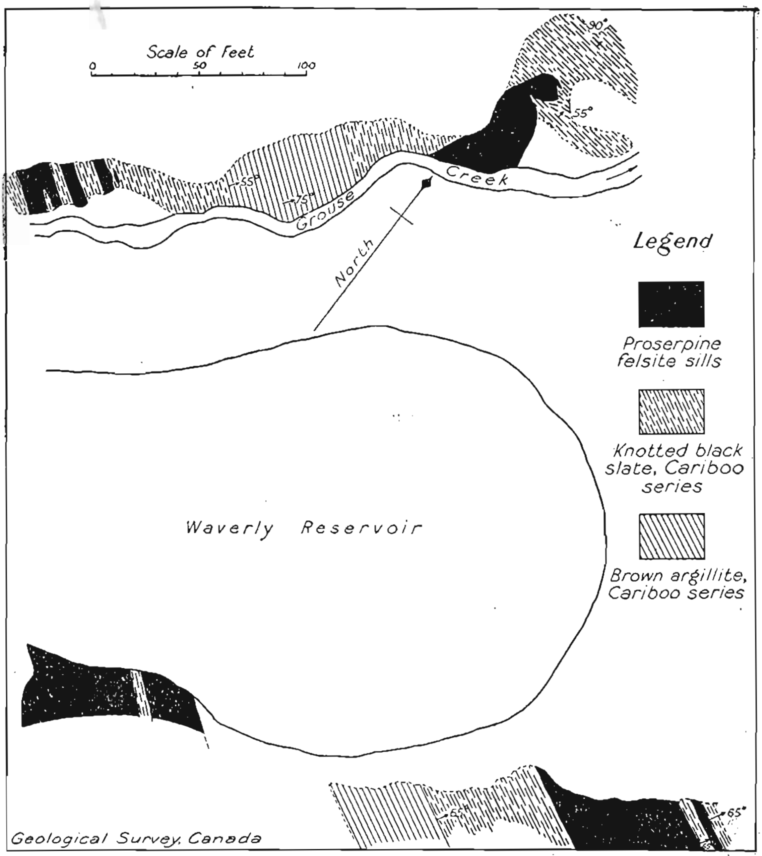

Figure 1. Proserpine sills in argillites and slates, in the vicinity of Waverly reservoir.

disseminated pyrite and siderite. Since they occur to a very large extent as sills and since the intruded rocks are equally oxidized in most cases, their outcrops and boundaries are not very clearly delineated. 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. Several sills of aplite or felsite are exposed at the head of the hydraulic pit of the Waverly mine on Grouse creek. An accurate detail sketch of this area was made in the field (Figure 1), which shows quite clearly the cross-cutting relations of some of these minor intrusives. Contact metamorphism of the adjacent slates and phyllites has produced along the borders of the sills 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, as at the Waverly pit just mentioned, 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. In other places, the replacement by siderite is not so complete, and the true nature of the rock can easily be read from a thin section. In these intermediate or transition facies, the siderite appears in the thin section as if the rock had been daubed with pale, buff-coloured paint, the daubs spreading across several of the mineral grains irrespective of their character or shape. In other localities dykes and sills of felsite and quartz porphyry occur in which the replacement has been slight, and from these the petrography of the intrusives is largely derived. Two of these occurrences are on Shepherd creek and on the Kitchener claim on Proserpine mountain.

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 Goldfields hydraulic ditch.

Age and Correlation. 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. All the available evidence, therefore, indicates that their intrusion was pre-Mississippian.

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 north-eastern and northern parts of the area. The following description of the series is given by Bowman:[1] "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."

In the light of the recent survey and investigation, 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 occurring 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 splendid 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.[2]

Age and Correlation

As noted subsequently in the detailed description of the fossiliferous Greenberry formation, 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. There is a general similarity in the lithology and stratigraphical sequence of the formations in both series, as shown in the accompanying table:

[1]Geol. Surv., Canada, Ann. Rept., vol. III (pt. I), pt. C, pp. 20–22 (1889).
[2]McConnell, R. G.: "Portions of Portland Canal and Skeena Mining Division, Skeena District, B.C."; Geol. Surv., Canada, Mem. 32.

Cache Creek series, Kamloops map-area[1]	*Slide Mountain series, Barkerville map-area*
Marble Canyon limestone with some minor intercalations of volcanic rocks, argillites and cherty quartzite, at least 3,000 feet thick	Limestone—grey to white, finely crystalline, thickly bedded series with some chert (exposed along Bear river, Swamp river, Spectacle lake, etc.)
Volcanic materials and limestones with some argillites, cherty quartzites, at least 2,000 feet thick	Thinly interbedded, grey and green cherts and argillites of the Antler formation 3,500 + feet thick.
Cherty quartzite, argillites, volcanic materials, and serpentines with some limestone (crinoidal), at least 4,500 feet thick	Basic volcanic rocks of the Waverly formation 2,000 + feet thick. Greenberry limestone (crinoidal) 400 feet thick
Base unobserved	Guyet basal conglomerate 900 feet thick

Richardson's discovery of *Fusulina* in the Marble Canyon limestone in 1871[2] fixed the age of the upper part of the Cache Creek series as Carboniferous and probably Pennsylvanian, whereas the determination of the Mississippian age of the Greenberry limestone, lying at the base of the cherts and argillites which are so typical of the lower part of the Cache Creek series, rather definitely fixes the entire Cache Creek series as Mississippian to Pennsylvanian.

Guyet Formation

Distribution. 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. It occurs in a narrow belt trending northwest from the type occurrence on mount Guyet along the southwestern slopes of mount Howley, Waverly mountain, mount Greenberry, and mount Murray to Two Sisters mountain beyond the northern border of the map-area. The best exposures of the formation 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.

Lithology. The formation grades in character 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 the presence of 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

[1] Geol. Surv., Canada, Ann. Rept., vol. VII, pt. B, p. 46 (1895).
[2] Geol. Surv., Canada, Rept. of Prog. 1877–78, pt. B, p. 88. Quart. Jour., Geol. Soc., vol. 35, p. 69.

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 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

Distribution. 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 of this formation 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.

Lithology. The formation is entirely 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*.

Age and Correlation. Careful examination of the Two Sisters Mountain and Mount Greenberry localities resulted in the recovery of a fragmentary suite of fossils, which were submitted to E. M. Kindle, of the Geological Survey, for determination. Of this collection and of the age of the formation, Mr. Kindle says, in part, as follows: "Specimens of limestone consisting chiefly of large crinoid column sections comprise the bulk of the material. Several specimens of a coral resembling, so far as can be judged from the poorly preserved material, a *Zaphrentis,* are present. Two brachiopods with obscure features which may represent *Spirifer keokuk* and fragments suggesting an *Orthoceras* complete the fauna as represented by this collection. Notwithstanding the limited number and extremely unsatisfactory state of preservation shown by these fossils, I have no doubt that they represent a Carboniferous fauna probably of Mississippian age. The material, however, is not good enough to demonstrate this correlation of the fauna."

This palæontological record, together with the lithology of the formation and its position a few hundred feet above the base of the series, seems to establish without much doubt the correlation of the Greenberry limestone and the lower part of the Slide Mountain series in general, with the lower part of Dawson's Cache Creek series of the Kamloops map-area. In regard to the lower limestones, Dawson[1] says: "The limestones found in the lower part of the formation (Cache Creek) to the east of the main syncline are seldom more than a few hundred feet in thickness and often much less. They frequently prove on microscopic examination to be composed chiefly of crinoidal debris, but often contain *Fusulinæ* and other foraminifera, as well as fragments of polyzoa and molluscs."

Waverly Formation

Distribution. The Waverly formation occupies a stratigraphical position 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 during the progress of the field work 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.

Lithology. 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.

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[1]Geol. Surv., Canada, Ann. Rept., vol. VII, pt. B, p. 42 (1895).

Antler Formation

Distribution. 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.

Lithology. 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.

Age and Correlation. Similar formations of interbedded chert (called cherty quartzite) and indurated shale (called argillite) are characteristic of the lower part of the Cache Creek and equivalent series in British Columbia. Dawson[1] describes a similar formation in the western part of the Kamloops map-area as follows: The cherty quartzites "generally occur in well-defined beds of a few inches only in thickness and often form great masses of strata. They are very fine grained, resembling hornstone or chert, usually grey in colour, passing to black in one direction and to yellow-grey and nearly white in the other, but occasionally greenish-grey. Almost everywhere they are traversed by innumerable veinlets and threads of white quartz. The bedding planes are often black and lustrous, and black, glossy argillite-schist is frequently associated with them. These rocks have evidently been silicified subsequent to their deposition, but perhaps very soon after, for it is pretty clear that they were much in their present condition before the main period of disturbance by which the formation has been affected. . . . .

"The argillites are generally hard and dark-coloured, ranging from black to grey. They are often schistose and sometimes show more or less slaty cleavage. In some places they are largely siliceous and evince a tendency to pass into the cherty quartzites."

[1]Geol. Surv., Canada., Ann. Rept., vol. VII, pt. B, pp. 40–41 (1895).

Drysdale[1] describes a similar formation in the Bridge River map-area in the following terms: "The Bridge River series is composed of metamorphosed sedimentary formations with interbedded volcanic rocks. The chief sedimentary member of the series is a bluish-grey chert which is much contorted in places. The chert grades into a cherty quartzite traversed by small branching veinlets of white quartz generally normal to the bedding plane, and locally known as 'Crowfoot' quartzite. The cherty beds occur in bands one-half inch or more thick, and often form great thicknesses of strata. Each narrow band is separated from the next by thin layers of argillite. . . . The cherty quartzites are very fine-grained like hornstone or chert. . . . The argillite members are composed of thin-bedded, dark argillaceous strata highly siliceous in places, with a tendency to pass into chert."

Cairnes[2] describes a similar formation in Coquihalla area, B.C., as follows: "A massive, dark-blue, and exceedingly fine-grained, cherty formation, usually minutely intersected with numerous quartz veinlets and interbedded with considerably slaty or argillaceous material and some calcareous beds . . . With the dark cherty rock is often associated a lighter coloured variety, commonly occurring in thin, but regular, bands or ribbons an inch or so wide, and separated by thin, argillaceous partings. They are commonly minutely crumpled and contorted."

On stratigraphical, lithological, and palæontological grounds, therefore, 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.

JURASSIC (?)

MOUNT MURRAY INTRUSIVES

Distribution. 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 outlines of 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 2); 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.

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[1]From unpublished manuscript quoted in Mem. 130, Geol. Surv., Canada, p. 23.
[2]Geol. Surv., Canada, Sum. Rept. 1920, pt. A, p. 26.

Lithology. 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.

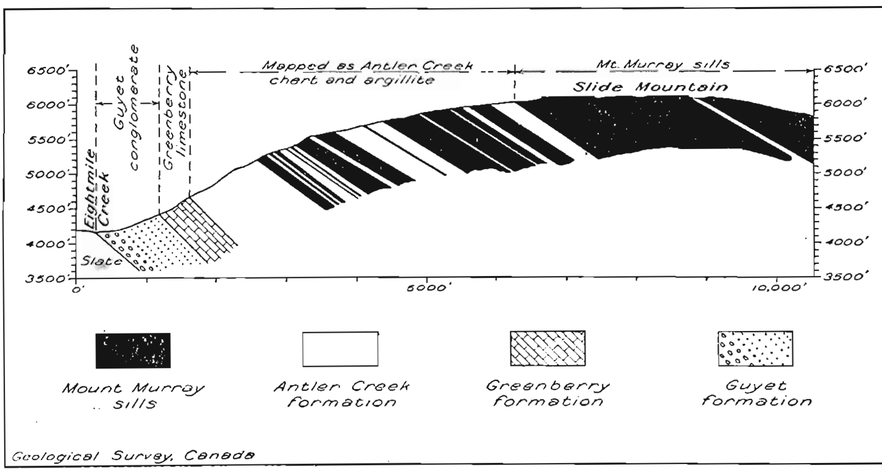

Figure 2. Structure section, Slide mountain, showing lit-par-lit injection of Mount Murray sills into Antler Creek cherts and argillites.

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.

Metamorphism. 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.

Age and Correlation. 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 which they have suffered points 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 Milk 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 122 & 125, 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 descri bed 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 which 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 (Plate V A), 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 quantities 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[1] 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

[1]Dawson, G. M.: Geol. Surv., Canada, Rept. of Prog. 1876–77, p. 145.

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.

More detailed descriptions of the Pleistocene deposits and pay-streaks on some of the creeks in the area and on a few creeks outside the area are given in Chapter III.

GEOLOGICAL STRUCTURE

REGIONAL

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 the 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 which bear on the structure of the 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.

LOCAL

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.

Folding

The geological structure sections reveal the nature of the anticlinorium. The main structure consists of a broad, open fold, controlled by the Barkerville limestone formation, the heavily bedded, non-schistose, dark-coloured

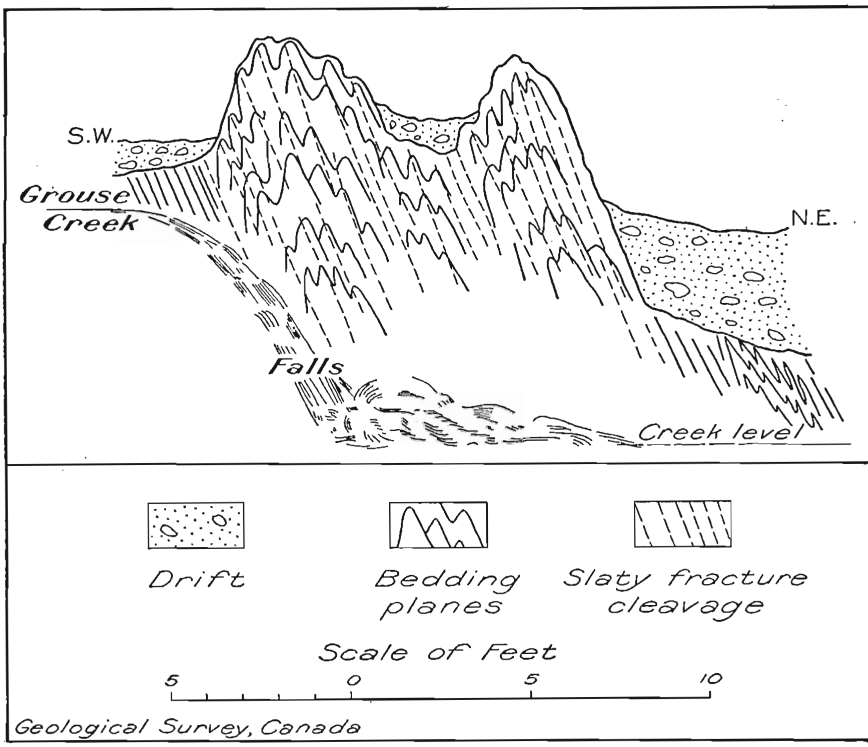

Figure 3. Structure section, Grouse creek, at falls below dam. Diagram shows intimate drag-folding on a subsidiary anticline in the Barkerville limestone, and slaty fracture cleavage strongly developed parallel to axial planes of drag-folds.

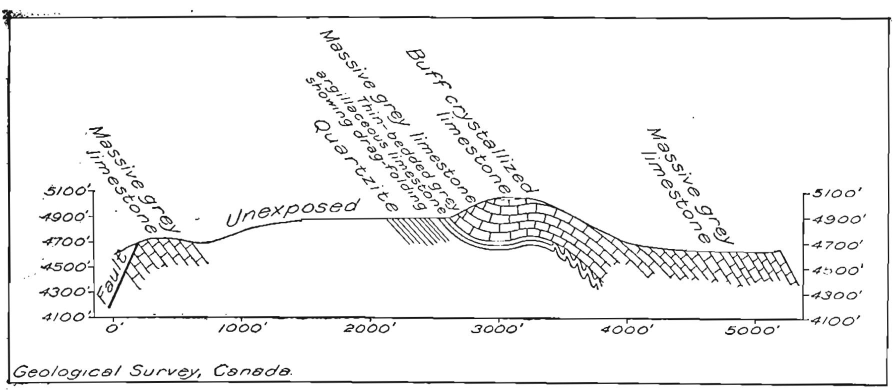

Figure 4. Structure section showing folding of Barkerville limestone between Waverly mountain and Pleasant Valley creek.

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 (Plate XIII). The black line pattern used on the geological structure sections represents an attempt to picture the character and intensity of the folding in each formation.

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. This statement may be well illustrated by reference to Figures 3 and 4 and Plates X and XI which show intimately drag-folded parts of the Barkerville limestone. 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 slates (Plate XII). 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[1] 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 the 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

[1]Op. cit., pt. C, p. 24.

cleavage ∥ axial planes of minor folds, ∴ Strikes OK but dips not always reliable

repetition of beds
dip and strike
thickness of fms.

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 (Plate XII). 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 (Plate XII A). In other words, the flow cleavage planes were seen to be parallel to the axial planes of the drag folds (Plate XII A, C). 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.

thickness

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 the Cariboo range prevents a more definite statement of these structural relations.

Faulting

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

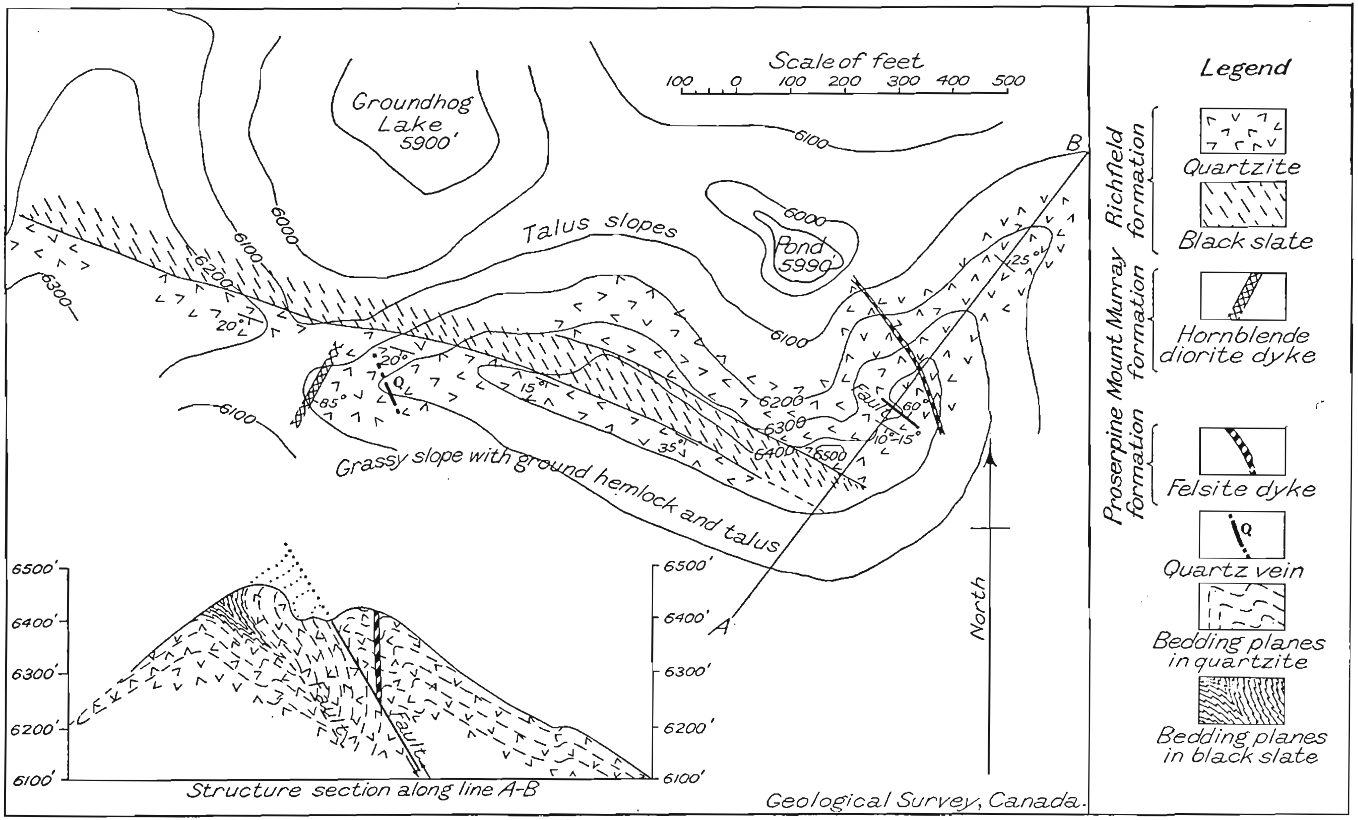

Figure 5. Geological structure of mount Agnes.

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 and Figure 5). 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 formations, 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 which 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 which runs down Grouse creek and across Antler creek; and the one which 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[1] 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 that accompanying this report 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.

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[1]Op. cit., pt. C, p. 23.

(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

A definite sequence of events may be inferred from the previous account of the geology and structure of the formations, but only one of the events —the deposition of the Greenberry formation—can with any degree of accuracy be fixed in the geological time record. Previous and subsequent events can only be timed relatively to that period of deposition. The general similarity of sequences and of lithological and structural rock types in other better known districts may be used with caution to assign approximately definite times to these other events. This method has been adopted to a considerable extent in the summary of the geological history which follows.

PRECAMBRIAN (?) RECORD

The tentative assignment of the Cariboo series to a place in the Precambrian record is based on its general lithological and structural similarity to the Beltian terrain elsewhere in British Columbia and to the fact that the unconformity beneath the Slide Mountain series (Mississippian) indicates that the Cariboo series was subjected to orogenic stresses, transformed into schists, quartzites, and slates, intruded by dykes and sills and considerably eroded prior to Mississippian time.

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

Subsequent to the time of 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 Proserpine 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).

PALÆOZOIC RECORD

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,[1] of Pennsylvanian age.

[1] Geol. Surv., Canada, Ann. Rept., vol. VII, pt. B, p. 39 (1896).

MESOZOIC (?) RECORD

Mount Murray Epoch

The next event in the historical sequence 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. These changes are described in detail in Chapter III.

CHAPTER III

ECONOMIC GEOLOGY

PLACER MINING

MINING METHODS AND COSTS

In the early days of mining, the claims were only 100 feet long and the necessity of forming "companies" to work the ground was recognized even during the first year of active mining and especially after the discovery, late in the autumn of 1861, that the main pay-streak in the lower part of Williams creek was deeply buried and could be mined only by sinking shafts through the overburden. The shallow ground on Antler creek and in the upper part of Williams creek was mined by open-cut work, and the gravels were washed with rockers and sluice-boxes. On Williams creek there were at work in 1862, one hundred and sixty-nine companies owning seven hundred and twenty-seven claims.[1] By June 10, 1863, the number of claims was three thousand and seventy-one. The mining population in 1862 was about twenty-five hundred and about four thousand in 1863. Peter O'Reilly, Gold Commissioner in Cariboo 1862-63, reported[2] that the Hard Curry (Diller) claim, consisting of three full interests (300 feet) on Williams creek below the canyon, produced from February 19, 1863, to May 9, 1863, $170,448 in gold, the total cost for mining and development work having been $34,472. Two shafts were sunk to a depth of 60 feet at an aggregate cost of $7,724. He reported also that the Grier claim—also on Williams creek but above the canyon—consisting of five full interests, produced from May 24, 1862, to October 24, 1862, $100,111 at a cost of $28,366.

In the early sixties wages amounted to $10 to $16 a day and board was $35 a week. The cost of supplies in general was very high, as the freight rate from Yale was $1 a pound. When the wagon road was completed to Barkerville in 1865 the freight rate was reduced from 75 cents to 15 cents a pound. In the seventies wages fell to $5 to $7, and that of Chinese labour to $3 a day, and the freight rate averaged 9 cents a pound.[3] Drift mining in the early days was not profitable unless the ground—that is the 5 to 10 feet of gravels on bedrock—had an average gold content of at least $4 or $5 a cubic yard. The gold values found in the old workings are usually reported as so many ounces to the set. The size of the sets varied according to the length of the cap and unless this was stated there is no way of telling how many cubic yards a set contained. The

[1]Trimble, William J.: "The Mining Advance into the Inland Empire"; Bull. of the Univ. of Wisconsin, No. 628, p. 48 (1914).
[2]Ibid, p. 49.
[3]Dawson, G. M.: Geol. Surv. Canada, Rept. of Prog. 1876-77, p. 113.

usual size was 10 feet (cap) by 6 feet by $3\frac{1}{2}$ feet, or a volume of very nearly 8 cubic yards. The cheapest drifting on a fairly large scale was probably at La Fontaine mine, where the underground costs, omitting pumping and overhead charges, were about $1.65 a cubic yard. This was about 1905, when labour costs were much less than they are now. Wood for fuel was then laid down at the mines for $2.50 to $3.50 a cord, whereas at the present time it costs $6.50 to $7.50 a cord. Labour costs now are about $5 a day, as compared with $3.50 a day twenty years ago. The cost of supplies in general has not been materially reduced, except that the freight rate on heavy machinery from Vancouver to Barkerville is now only $3\frac{3}{4}$ cents a pound as the result of the construction of the Pacific Great Eastern railway to Quesnel. At one time freight rates from Ashcroft to Barkerville were as low as $4\frac{1}{2}$ cents a pound, but for a few years previous to the construction of the railway they averaged about 8 cents a pound. Mine timbers formerly cost 6 to 8 cents a foot and lagging 6 to 7 cents a piece. In recent years most of the companies have installed sawmills and cut their own lumber for flumes, as well as blocks for the sluice boxes and mine timbers. There are several sawmills in the district, and spruce lumber can be readily obtained at about $60 a thousand. Pumping and hoisting costs for fuel alone at the former drift mines, such as La Fontaine and Slough Creek, averaged from $20 to $25 a day. The amount of water pumped averaged nearly 1,000,000 gallons a day. A great saving was effected at some of the mines—for example at Willow river—by installing a 25-foot water wheel, which pumped nearly as much water at a nominal cost. There are no large drift mines in operation in the district at the present time, but, if in the future much pumping is necessary, the cost will be prohibitive unless waterpower be available or the ground exceptionally rich.

Hydraulicking in Barkerville area began at the Black Jack cut on Williams creek and was carried on there and at the Forest Rose lower down on the creek, for over forty years. Hydraulicking is responsible for most of the gold production of the past twenty years. Possibly the cheapest hydraulicking in the areas was done in 1920 by C. W. Moore on the Waverly property, on Grouse creek, when nearly 200,000 cubic yards of ground were mined at a cost of about 4 cents a cubic yard. The costs vary up to 15 cents a cubic yard, the average probably being about 8 cents. In hydraulicking most of the operators strongly favour using part of the water as a ground-sluice or by-wash, especially where, as at Lowhee mine (Plate VII B), a vertical fall, for the water, of considerable height, can be maintained at the head of the pit. The use of a single large monitor instead of two smaller ones is also preferred. Hydraulic elevators have been used at several places in the area and have proved fairly effective where the lift was small, but an attempted lift of 100 feet by the Gold Fields Company, in the lower part of Williams creek, about 1900, resulted in failure because of the excessive wear and tear on the machinery and the low efficiency of this method of mining. An hydraulic bucket-elevator was tried by the same company, but also proved a failure. In hydraulicking, the minimum grade for sluice-boxes is 4 inches to the 12-foot box, and grades of 5 or 6 inches are most commonly used in the district.

Drilling to test the depth and gold values of possible drifting or dredging ground was first done in the area about 1895, with an "hydraulic jetting machine." Casing was used, and water was forced down the drill stem and up the inside of the casing. Some excellent work resulted in determining the depth of the ground, especially at La Fontaine on Lightning creek, but apparently no reliance was placed on this method as an indication of the gold values. Indeed, some of the most disastrous failures in drift mining were due to the fact that the gold values were not determined before mining was undertaken. Only during the past ten or fifteen years has it been generally recognized in the district that the drill is one of the most effective and cheapest means of testing the ground. Small portable Keystone or Standard drilling rigs, and occasionally hand drills, have been used in recent years, and much of the ground has been tested. Comparing the gold values as determined by drilling with those later obtained by extensive dredging in California, Alaska, and other places, it is now generally conceded that "Employing the outside diameter of the casing as a basis for calculating the volume of the core has been found in practice to give high results. A pipe formula reducing the value of these results, and based on check shaft-tests made by W. H. Radford, has been generally accepted. This formula reduces the results obtained by the theoretical formula about $14\frac{1}{2}$ per cent. In its simplest form it is as follows:

$$\text{Value of gravel per cub. yd.} = \frac{\text{Value of gold obtained} \times 100}{\text{Depth of hole in feet}}$$

When drilling has been carefully done, 75 to 80 per cent of the estimated yield can be recovered by the dredge. This includes all losses, not only those in the tailings, but unrecoverable islands and corners left behind in the course of operations. In Alaska, however, where the ground is shallow, the gold coarse, and on a shattered bedrock, dredging results have usually exceeded the estimated yield, the percentage of recovery being from 103 to 198. When these high recoveries have been obtained, the dredging depth has always been greater than the drilled depth, in cases as much as 30 to 40 per cent."[1] Drilling in Barkerville area in 1915 cost the Yukon Gold Company about \$2.50 to \$3 a foot. Other recent drilling has cost considerably more, probably nearly \$5 a foot.

Dredging has only recently been undertaken in the area. The costs are estimated at 10 to 11 cents a cubic yard, or somewhat greater than the cost of hydraulicking, but this is largely offset by the fact that dredging can be carried on for about ten months in the year, whereas the average hydraulic season is only about five and a half months.

The cost of constructing ditches in the area varies from \$2,000 to \$5,000 a mile depending upon the size of the ditch, the amount of rock work, fluming, etc.

CLIMATIC CONDITIONS AND WATER SUPPLY

Records of climatic observations at Barkerville are available[2] from 1888 to 1924.

[1]Haley, Charles Scott: "Gold Placers of California"; Cal. State Min. Bur., Bull. No. 92 (1923).
[2]Reports of Meteorological Service of Canada, Toronto, Ont.

Mean Temperature at Barkerville, 1888-1915 (Degrees F.)

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
16·4	19·2	26·1	34·8	44·4	50·1	54·4	53·7	45·5	37·7	25·3	20·9	35·7

The temperature rarely rises above 80 degrees or falls below −20 degrees and in some years these extremes are not reached.

Mean Precipitation at Barkerville, 1888–1923 (Inches)

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
3·37	2·51	2·40	2·11	2·56	3·49	3·25	3·21	3·51	3·18	3·45	3·43	36·47

The precipitation in 1908, the wettest recorded year, was 49·54 inches; the precipitation in 1896, the driest, was 20·61 inches. The years 1917 to 1922 inclusive were exceptionally wet, the precipitation each year being over 40 inches and averaging 43·35 inches. They were preceded by a long series of relatively dry years interrupted by an occasional wet year. In only four years during the period from 1888 to 1916 did the precipitation exceed 40 inches. The precipitation in 1923 was 36·68 inches or very nearly the average for thirty-six years. The average winter's snowfall is 188 inches. It varies greatly from year to year. In the winter of 1904-05 it was only 97 inches; in the winters of 1916-17 it was 258·3 inches.

The water available for hydraulicking is mostly derived from the levels above 4,500 feet, and, therefore, comes chiefly from melting snow. The amount available in any season depends on the amount of snowfall during the preceding winter, on the way in which the snow melts in spring and early summer—whether gradually or rapidly—and on whether or not it disappears largely by evaporation. Comparatively little melting of the snow occurs during most winters, although thaws occasionally occur and cause some increase in the run-off which is ordinarily very low during the winter, especially at the higher levels. Below about 5,000 feet there is some run-off during the winter because of the flow from springs, the temperature of the ground water throughout the year being about 36 degrees F. or practically the same as the mean annual temperature. In some years a sufficient flow of water has been available on a few of the creeks to operate water-wheels throughout the winter. Fairly extensive thaws, followed by freezing temperatures, occasionally occur in March or April before the usual time of opening of the hydraulic season and before preparations for hydraulicking are completed. If the snowfall be heavy it is necessary to clear the ditches to a depth of several feet; otherwise, the water is likely to be dammed by the snow and to cause washouts in the ditch. If the snowfall be light it is necessary merely to work the ditches ahead of the water. The flood water in the spring lasts, as a rule, from three to six weeks, but in some years only one or two weeks. The run-off gradually decreases during the summer, and reaches a minimum for the summer months in August or in the early part of September. It again increases in the latter part of September and October, so that there is generally sufficient water for a "fall run." The hydraulic season in some years begins in the latter part of April, but usually begins in May and lasts until the latter part of October. The average length is about 170 days. About 20 days of this time on an average have to be allowed for "clean-ups."

The amounts of water available for hydraulicking at different places in the area, or which can be made available by the construction of ditches, can be determined if the drainage areas and the average run-offs for these areas are known. The drainage areas, except in the case of those which are partly outside the area covered by topographical maps, can be determined from the topographical map by tracing on cross-section paper the boundaries of the drainage basins as shown by the contours and streams, and thus determining the areas within the boundaries, or a planimeter may be used. The average run-offs of the streams are not known, because measurements are not available except for short periods. They may be approximately determined by means of the relationship which exists between precipitation and run-off in the area. The average annual precipitation at Barkerville for thirty-six years is 36·47 inches. This amount is probably nearly the true average for the whole area, for the meteorological station is situated near the central part of the area, at an altitude of 4,200 feet. For the higher levels, however, the average is probably slightly greater. The surface run-off of streams in any region is derived from the precipitation, but, as a general rule, forms only about one-third of the total precipitation, for a large part of the precipitation is returned to the atmosphere by evaporation and by transpiration from vegetation, and a part passes into the ground water and does not reappear as springs in the drainage basin.

The mean annual run-off of Fraser river at Hope from 1912 to 1922, as determined by the Dominion Water Power Branch of the Department of the Interior, was equivalent to a depth of 15·61 inches of water over the entire drainage basin of the Fraser. The average annual precipitation at twelve meteorological stations in the Fraser drainage basin was 18·72 inches. All the stations, however, with the exception of Barkerville where the average precipitation was 40·89 inches, are situated in the valleys at comparatively low elevations where the precipitation is much less than in the higher parts of the basin, from which the great part of the drainage waters come. The precipitation in these higher parts probably averages about the same as at Barkerville, but may be somewhat higher. It is known that, as a rule, no run-off occurs in the United States in drainage basins where the average precipitation is less than 18 inches.[1] In central British Columbia the proportion of run-off to precipitation is higher because of the higher latitude and less evaporation, but the run-off from a considerable part of the drainage basin of the Fraser in south-central British Columbia, where the average precipitation is only 7 to 21 inches, must be very small. The proportional run-off from the higher parts of the basin, must, therefore, be fairly high and is probably about one-half the precipitation. Unfortunately no records of discharge of the Fraser at Quesnel or at points higher up stream are available. Discharge records of the North

[1]Hoyt and Groner: "River Discharge," 1920, p. 156.

Thompson at a point 40 miles above Kamloops are available from 1915 to 1922. They show an average run-off of nearly 25 inches over the drainage basin, the higher parts of which are fairly similar to Barkerville area. The annual precipitation over the drainage basin is known to be slightly greater than at Barkerville and probably averaged between 45 and 50 inches during the period, or about double the amount of run-off. It is probable, therefore, that the run-off in the Barkerville area is about one-half the precipitation.

Weir measurements of many of the streams were made by the present writer in August and September, 1923, during which year the precipitation was practically the same as the average for thirty-six years. The average run-offs (depth of water over the drainage basins) of the creeks during August and September were determined from these measurements and from the areas of the drainage basins. In most cases it was found that the run-offs for these months were only one-fifth of the precipitation. The run-offs for the other months of the year were then determined by assuming that the run-offs are proportional to those which obtain in the drainage basin of the North Thompson, for which monthly records are available. The results indicate that the average annual run-off is about 20 inches and the run-off during the hydraulic season about 16 inches.

The run-off may also be approximately determined according to Meyer's method,[1] by determining the average annual evaporation and transpiration and deducting these amounts from the precipitation. Meyer has constructed a series of curves from which the mean monthly evaporation may be determined if the mean monthly temperatures are known. According to this method the mean annual evaporation at Barkerville is 13 inches and transpiration from vegetation 4 inches. This leaves a balance of 19·47 inches as the mean annual run-off which is practically the same as determined by the stream flow method. There are also some losses by underground seepage, but they are probably very slight in the higher parts of the region.

The estimate of 16 inches for the run-off during the hydraulic season applies more especially to the higher parts of the region above 4,500 feet. The run-off from the lower parts is less, because evaporation and underground flow in the drift-filled valleys of the lower parts is much greater than in the higher parts, where there is comparatively little drift and where the slopes are steep, and is probably about 12 inches. The amount of water available for hydraulicking or other purposes at any point in the area may, therefore, be approximately determined. For example, the area above the Stouts-Lowhee system of ditches is 306,000,000 square feet. The total amount of water, taking the average run-off as $1\frac{1}{3}$ feet, is 408,000,000 cubic feet. This amount is equivalent to 27·7 cubic feet per second, or 990 miner's inches throughout the hydraulic season.[2] In order to utilize all the water and to maintain a fairly uniform flow throughout the hydraulic season it is, of course, necessary to have one or more reservoirs to conserve the flood water. As the flow during the freshet is usually ten times as great as during the low water summer stage, and in some years is nearly thirty times as great, it is difficult to conserve all the flood water

[1] "Computing Run-off from Rainfall and Other Physical Data"; Trans. Am. Soc. Civ. Eng., Mar. 1915, pp. 549–648.

[2] A miner's inch according to British Columbia statute is a flow of water of 1·68 cubic feet per minute.

even if reservoirs be available. Some losses, also, are likely to occur because of leakages from the ditches, unless these be specially well constructed and flumed at places where the ground is porous. The actual amount of water available for hydraulicking is, therefore, somewhat less than as calculated above and depends partly on the manner in which it is used, and partly on the efficiency of the storage system. The amounts available at other places in the area, where determinations of the amounts are possible, are referred to in the descriptions of the creeks.

The average duty, in the district, of a miner's inch of water per 24 hours, is 1 to 3 cubic yards of ground, the amount varying with the head, character of the ground, and other factors. By taking the total amount of water available and the duty of the water, an estimate may be made of the amount of ground which may be handled yearly. In practice, and even with good storage reservoirs, the amount of water available during the freshet will be much greater than at other times. It is, therefore, necessary to provide a ditch to carry a fairly large flow. For example, at Lowhee mine the main ditch is 7 feet wide at the top and 4½ feet at the bottom and carries 1,500 miner's inches of water, the amount that is used to supply one large monitor during a considerable part of the season. The excess water is used as a ground-sluice and when a full head is not available for the monitor the plant is shut down and the water stored, or the plant is operated only during a part of the day or week.

There are no falls suitable for the development of waterpower, but there are a few places where small amounts of power might be developed by the construction of dams. Willow river, a short distance below the junction of Slough creek, flows through a rock canyon 100 to 150 feet wide and 30 to 50 feet deep. The flow of the river above the canyon on August 14, 1923, was 34·5 cubic feet per second, which is about the average low water summer flow. A dam 30 feet high would develop 94 horsepower, 80 per cent efficiency, at low water. The drainage area is 74 square miles and the only storage available is Jack of Clubs lake. As the winter flow is somewhat less than the low-water summer flow, the amount of power that can be made available throughout the year is less than 94 horsepower. The rock canyon of lower Antler creek, which has a larger flow than Willow river, also affords an opportunity for the development of waterpower by the construction of a dam. The most important falls in adjacent districts are the two on Swamp river about 30 miles east of Barkerville. One is a few miles below the outlet of Isaac lake and is said to be 60 to 70 feet high; the other is a short distance below the outlet of Sandy lake and has a direct fall of 50 to 60 feet. It is estimated[1] that 1,000 horsepower can be developed from the latter. Waterpower can also be developed by a dam at the foot of Bowron (Bear) lake, 20 miles northeast of Barkerville. In Barkerville area a head of 700 or 800 feet can be obtained at several places by means of ditches, but the water, except on Lightning creek, is mostly in use for hydraulicking. There would be difficulty, also, in maintaining the flow throughout the year unless good reservoirs were provided.

Water of good quality for domestic purposes is readily available throughout the area either from the creeks themselves or from springs

[1] "Water Powers of British Columbia"; Commission of Conservation, Canada, p. 254.

which occur abundantly, especially at altitudes between 4,000 and 4,500 feet and flow the year round.

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 specially 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 disintergration 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 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 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

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

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.

The Pleistocene deposits (glacial drift) and the Recent alluvial deposits have been described in the chapter on "General Geology." The placer deposits on the several creeks are more particularly described in the following description of the creeks.

DESCRIPTION OF THE CREEKS

The creeks of the area mostly radiate from the central high part of which mount Agnes forms the summit. They are herein described in order from east to west. A few creeks adjacent to the map-area on which there is a probability that further work will be done are also briefly described. They include Valley, Summit, Dragon, Fountain, and Peters creeks, and Swift river. Accounts of mining and prospecting already done on the creeks, as well as a short description of each and its mining possibilities, are given. A complete history of mining in the area is not attempted, for mining has been carried on since 1860 and it has been deemed sufficient to describe only such work as appears to have a bearing on present day mining and future possibilities. Much of the evidence regarding early mining is hearsay, but most of it is derived from eye witnesses and it seems desirable to place it on record, for probably not more than half a dozen of the "old timers" are living. This information and even some of a later date cannot be guaranteed, but is believed to be correct. Parts of Antler and Williams creeks have already been described[1] and are referred to only incidentally in this report.

[1]Geol. Surv., Canada, Sum. Rept. 1921, pt. A, pp. 59-71.

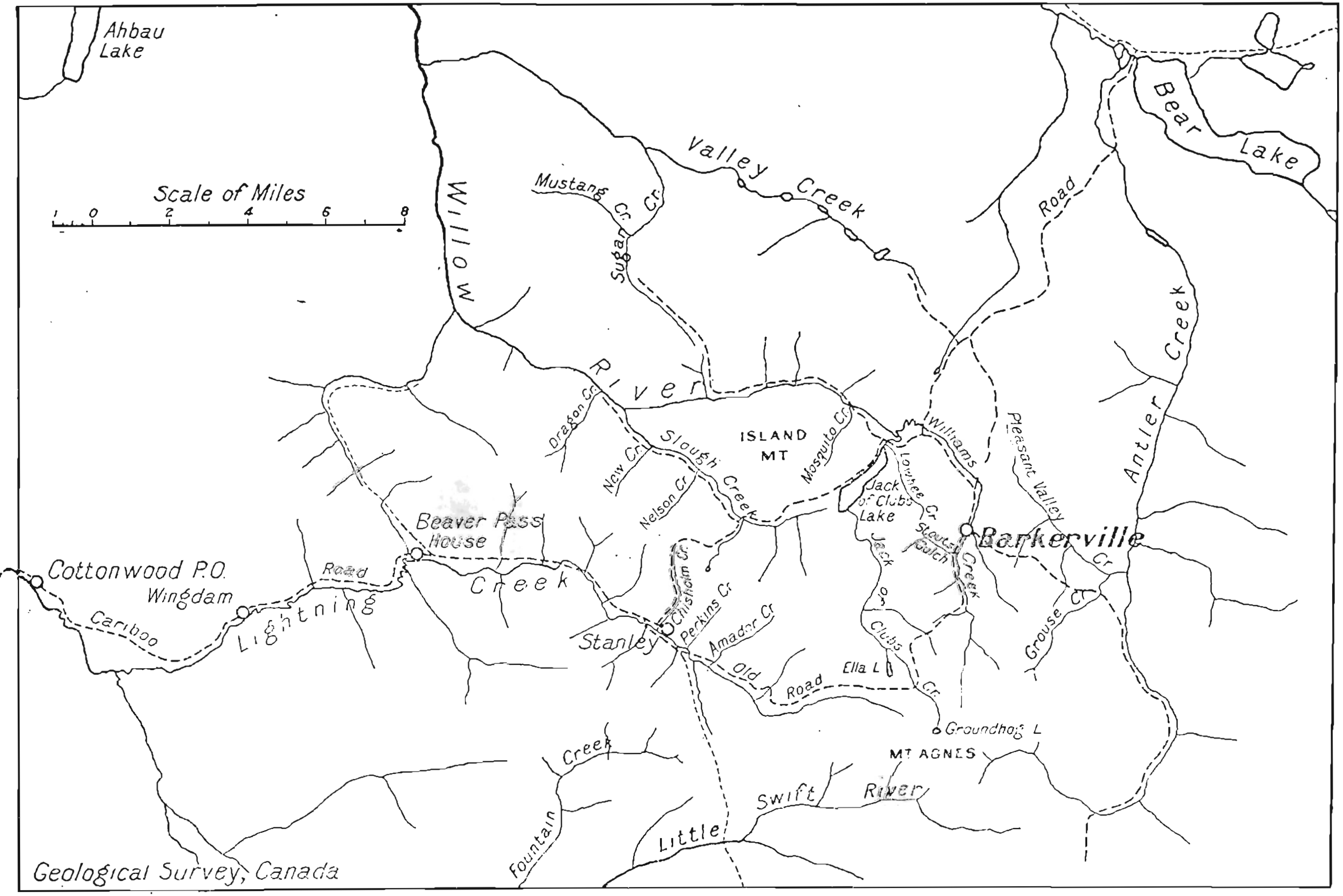

Figure 6. Barkerville district showing location of streams.

The possibilities for placer mining in the area are mainly for dredging and hydraulicking. In addition to the dredging ground on Antler creek where dredging is being carried on by the Kafue Copper Development Company, there is possible dredging ground on the lower part of Williams creek from Barkerville to the Meadows; on parts of the Meadows opposite the mouths of the tributary creeks and opposite the Devlin bench and Forest Rose claim; on Antler creek from the canyon above the mouth of Grouse creek for about 2 miles down stream; on Pine and the upper part of Summit creek; at Eightmile lake and in the lower part of Valley creek, and in places in the upper parts of Swift river, especially in its lower part for $2\frac{1}{2}$ miles up from the junction with Lightning creek. There is sufficient ground for hydraulicking at Lowhee mine, at the Tregillus mine on Cunningham creek, at Slough creek, and at other places in the area, to ensure continuance of the work for several years, and the possibilities include a large area on Conklin gulch as well as a few other smaller areas. It seems probable, therefore, that although this mining camp already has had an exceptionally long life as compared with that of many other alluvial fields, it will produce gold for many years to come, and that the gold production for the next ten years will be materially greater than that of the last decade.

The maps of the creeks (Figures 7 to 30)accompanying this report were prepared in 1922 and 1923. They were done on a field scale of 800 feet to the inch by plane-table and telescopic alidade. The contours are drawn at 40-foot intervals and the elevations are referred to sea-level.

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 $1\frac{1}{2}$ miles from near the mouth of Victoria creek, the first tributary on the south side below Sawmill flat. Here, the ground was on the average only 6 feet deep; there was no overburden of barren clay and the surface gold-bearing gravels were easily and cheaply mined, mostly in one season, by rocking and sluicing down to bedrock. Along this stretch of the creek the valley bottom is comparatively wide and has a low gradient. Near the mouth of Nugget gulch, the next tributary below Victoria on the east side, a channel which is apparently a continuation of the Antler channel, leaves the Main Creek valley and extends a short distance up and across Victoria creek. This channel, partly filled with glacial drift, was also mined out in the early days. Little gold was found in the upper part of Victoria creek. 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 dredging ground on the Nason and Lothair claims already described.[1]

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.

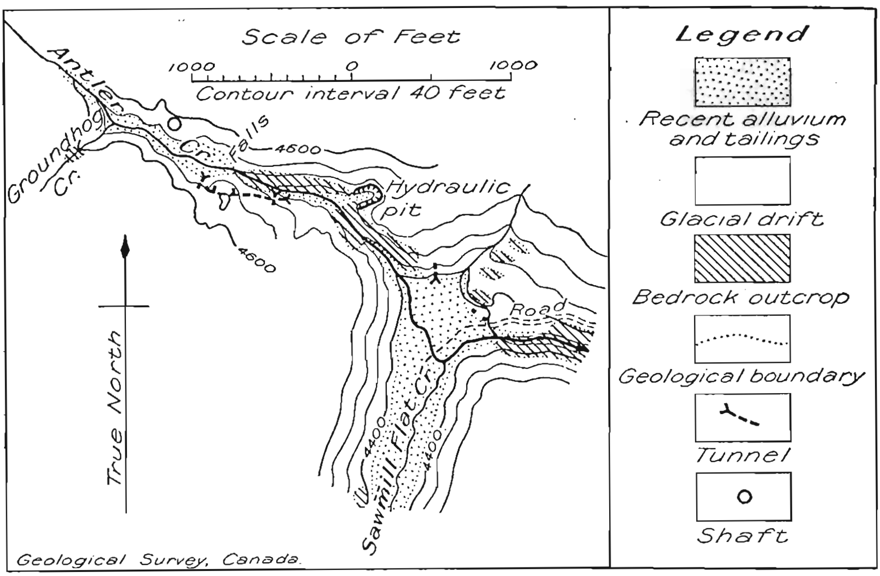

Figure 7. Sawmill flat, Cariboo district.

Sawmill flat, ~~the lower part of which is shown on Figure 7~~, extends south from the great bend of Antler creek above Victoria creek, for about $1\frac{1}{2}$ miles, to a low divide at the headwaters of one of the branches of Swift river. Littler's cabin, a well-known stopping-place on the old trail from Keithley to Barkerville, is at the head of the flat near the summit. The valley is remarkably flat-bottomed and has a very low gradient. At the

[1] Johnston, W. A.: Geol. Surv., Canada, Sum. Rept. 1921, pt. A, p. 65.

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. It widens again above, but gradually narrows towards the head. Bedrock also outcrops near the cabins at the junction of Sawmill Flat creek and Antler creek and in the bed of Antler creek a short distance below the junction. It is, therefore, probable that the depth to bedrock in the flat is not great, though it is possible that glacially eroded rock basins occur and that the ground is deep in places. 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[1] that gold was found in all the holes, but not sufficient to pay for mining.

Antler creek immediately above Sawmill flat ~~(Figure 7)~~ flows for 500 feet in a narrow rock canyon. The valley then widens, but 400 feet above again contracts to a narrow rock canyon at the head of which is a fall of about 10 feet over a hard rock ledge. Above the falls an alluvial flat of 100 to 200 feet wide, known as Maloney flat, extends to the mouth of Groundhog creek coming in from the south. Along this stretch of the creek considerable prospecting and mining development work has been done during the past twenty-five years. "Ten dollars diggings" were reported[2] to have been found in 1860 at Maloney flat. There is evidence of old surface workings on the lower part of Groundhog creek and along Antler creek for about one-half mile above the mouth of Groundhog creek. The narrow rock canyons with steep gradients through which the present creek flows, and the fact that the stream valley above and below the canyons is wider and flatter bottomed, indicated to the prospectors that an older channel, buried beneath glacial drift, occurs alongside the canyons and this was definitely proved by shaft sinking and tunnelling. Although the gold which had been found on the creek was mostly in the surface gravels resting on glacial clay and not in a definite pay-streak on or near the true bedrock, it was believed that a rich pay-streak would be found in the deep buried channel. The deep channel apparently crosses beneath the present creek opposite the small hydraulic pit on the left bank and extends upstream nearly parallel to the present stream for about 600 feet. Its course downstream from the hydraulic pit is not definitely known. In 1898 a company known as the Bradford, Cariboo, and Yukon Gold Fields, Limited, formed to prospect on Upper Antler creek and Nugget gulch, ran a tunnel 150 feet long on Antler creek, below the falls, at right angles to the present stream. The tunnel is the second one on the right bank above the hydraulic pit ~~(Figure~~ 2). At 20 feet from the mouth of the tunnel a blind shaft was sunk 4 feet to bedrock. At 117 feet, another shaft was sunk 47 feet to bedrock, the last 17 feet of which was in gravel in which a prospect of gold was obtained. At the

[1] Geol. Surv., Canada, Map 366 (1895).
[2] Ann. Rept., Minister of Mines, B.C., 1902, p. 118.

face of the tunnel the depth to bedrock was found to be 27 feet.[1] The position and depth of the buried channel at this point were thus determined. A second tunnel was then started 100 feet lower down Antler creek and nearer the level of the creek, and was run upstream for 450 feet along the course of the old channel. Where it passed beneath tunnel No. 1 it was about 7 feet above bedrock. In 1899 the property of the Bradford, Cariboo, and Yukon Gold Fields, Limited, was acquired by the Cariboo Deeps, Limited, a syndicate of which Mr. H. E. C. Carry, of Vancouver, is manager and chief stockholder. The tunnel was extended in 1900 and was found to be running with the steep rimrock of the buried channel close on the left hand. The channel was crossed in two places and was found to prospect better than the sides, the gold being coarse and well worn, but not in sufficient quantity to pay. The bedrock was hard and smooth and without crevices, and was, therefore, unfavourable for holding gold. Work was continued in 1902, but gold was not found in paying quantities. Water pressure in the deep channel also caused difficulties in prospecting.[2] In 1904 Henry Boursin relocated part of the ground formerly held by the Cariboo Deeps, Limited, and continued the tunnel in the hope of locating more favourable bedrock, but apparently was unsuccessful. The total length of the tunnel is 728 feet. In 1919 six of the stockholders of the company ran a tunnel in from the level of Maloney flat and sank a shaft to connect with the upper end of the tunnel, with a view to locating pay gravels and hydraulicking with Antler Creek water, but no further work was done.

The hydraulic pit on the left bank of Antler below Maloney flat ~~(Figure 2)~~ was opened up by J. Campbell and the Houser brothers, but did not pay, as the ground had been already drifted and the deepest part of the bedrock channel could not be cleaned out owing to its low level. Most of the pay is said to have been on a rock bench on the north side about 10 feet above the deep channel. A large amount of work has been done in searching for the continuation of this channel from the hydraulic pit down to Sawmill flat, thirty-one test pits and shafts having been sunk, one of which above the cabins at Sawmill flat is said to be 71 feet deep. A prospect tunnel was also run in 1915 from the level of Sawmill flat by Campbell and the Houser brothers. The tunnel is about 110 feet long and several side drives extend for short distances. Some gold was found, but no definite rock channel was located.

The most recent work along this stretch of Antler creek was done by Morris Anderson, who sank a shaft 40 feet deep on the left bank just above Maloney flat. He holds that a buried channel extends along the left side of the creek, since it was reported that a tunnel run from the level of Antler into the left bank about 100 feet above the mouth of Groundhog creek showed the surface of the bedrock to be dipping into the hill. It may be that the deep channel on the right side below Maloney flat crosses over above the flat, but sufficient work has not been done to determine whether this is so. The bedrock in the Anderson shaft is probably too high to be in this channel.

[1]Ann. Rept., Minister of Mines, B.C., 1898, p. 978.
[2]Ann. Repts., Minister of Mines, B.C., 1900, p. 234; 1902, pp. 93, 117.

The elevation of the bedrock in the lowest part of the buried channel at the Bradford tunnel is 4,430 feet; the bedrock in the lowest part of the hydraulic pit is 4,450 and the floor of the tunnel at Sawmill flat is 4,390. The bedrock in the lowest part of the old channel in the hydraulic pit is higher than in the deepest part of the buried channel where the Bradford tunnel was run higher up and on the opposite side of the creek. An old channel probably ran about where the tunnel is located, crossed the present stream valley at the hydraulic pit, and continued on the north side of the creek towards Sawmill flat; in the part along the Bradford tunnel it was eroded to its present depth prior to the deposition of the glacial drift which now fills it. The present channel of Antler creek below the hydraulic pit is in part a rock canyon or rather a V-shaped gorge, and forms the only possible outlet for the old channel. Therefore, it is probable that this part of Antler creek also was formed, in part at least, before the deposition of the latest glacial drift. The upper rock canyon is much narrower and is post-Glacial in age.

As the tunnel at Sawmill flat is 60 feet lower than the bedrock in the hydraulic pit, 700 feet upstream, it is probable that the tunnel is too low to intercept the continuation of the old channel, for it is unlikely that the grade of the channel is over 2 or 3 per cent. The old channel, however, can not be more than 50 feet above the flat and the bedrock outcrops north of the cabins at the flat show that the old channel does not extend past the small stream coming in from the north. It is possible that the channel in its lower part has been partly destroyed by glacial ice erosion.

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.

The material overlying the old channel to a depth of 50 to 100 feet along the course of the Bedford tunnel is mostly glacial clay. On the north side of Maloney flat, a washout from China Creek ditch has exposed a considerable body of glacial outwash gravels, which also occur in places along the supposed course of the lower part of the old channel. The section exposed in the hydraulic pit shows 20 feet or more of glacial clay underlain by gravels.

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.

The source of the placer gold in Upper Antler creek and its erratic distribution have been questions in dispute ever since the early discoveries. Although the first actual discovery on Antler in the autumn of 1860 was made in a post-glacial rock canyon between the mouth of Victoria creek and Sawmill flat, it was soon realized, especially after the discoveries of rich pay gravels in the wider, older parts of the creek bottoms, that the youthful rock canyons were likely to contain little gold. They in many cases indicated to the prospectors, however, that—as above Sawmill flat—a buried channel might occur alongside which could reasonably be presumed to contain pay gravels in the bottom. The new rock channels in many cases were caused by accumulations of glacial debris filling the old stream valleys in places and forcing the stream to cut a new channel around the obstruction. As the bedrock is usually close to the surface on the sides of the valley and is easily eroded, rock canyons were cut to considerable depths in post-Glacial time. Some were probably formed in much the same way during times of melting and comparative warmth during the Pleistocene or Ice Age. The post-glacial canyons are usually distinguished by their nearly vertical sides and the steep gradients of their bottoms; the older ones are more nearly V-shaped and have lower gradients. Thus the upper canyon above Sawmill flat is clearly post-Glacial and the lower probably Pleistocene in age. The reason why the recent rock canyons contain little gold is that, unless they happen to have cut across part of an older gold-bearing channel, they contain only the coarse gold derived from the wearing away of a limited thickness of rock, whereas in the old channels the gold represents the concentration from the wearing away of a great thickness of rock. Any gold sufficiently fine to be transported by a stream is likely to be carried through the canyons because of their steep gradients. A popular theory with the early miners was that slides from the mountain sides had blocked the old channels in places and had thus caused diversion of the streams. There is very little evidence of recent slides in the region, but they may have occurred more frequently before the mountain slopes became forested. But in any case the material forming the obstructions to the old channels is nearly always glacial drift and diversion has occurred because of its irregular deposition. Rock or talus slides, however, occur in a few places where the valley slopes are especially steep.

Some recent rock canyons such as that just below the rich ground on Antler creek, are different in character and origin from those just referred to. They occur in the bottoms of the main valleys, are formed by the headward erosion of the stream—as by the eating back by a falls—and are the result of a change in the gradient in the stream below. In such cases the increase in gradient of the stream below the canyon was probably due to local glacial erosion producing overdeepening of the main channel as has happened on Antler creek opposite the mouth of Wolfe creek where the upper part of the canyon is post-Glacial in age and the lower part probably late Glacial. Some gold was found on the rock benches along the canyon, whereas little was found in the steep, narrow part of the canyon itself. Even if a stream were eroding headward in a valley bottom containing a small thickness of gold-bearing gravels resting on bedrock, as was the case here, there would be little gold in the resulting canyon, for even the coarse gold would be pounded fine enough to be carried downstream to places where deposition was going on. A similar action takes place in the case of pot-holes in the bedrock. These rarely contain any gold because the pot-holes are ground out by stones being whirled around by the water currents and any gold in the hole is ground so fine that it floats away. In the rare cases in which placer gold is found in pot-holes, deposition has taken place after the holes were formed and the gold was necessarily fine enough to have been transported by currents along with the sand and gravel which fills or partly fills the hole.

In the lower part of the canyon just below Antler and for some distance below, deposition has followed erosion and a considerable body of gravels occurs which constitutes the known dredging ground of Antler creek. The gold is known to occur mainly on bedrock at the base of the gravels. It probably was transported mostly along with the gravels, which are partly Recent and partly Glacial in age, and has been gradually concentrated on bedrock by the action of the water flowing through the gravels. The porous character of the gravels on the Nason ground was shown by the fact that it was found necessary to flume the present creek when drifting of the ground was attempted. It has been stated, also, that within one or two hours after a heavy shower, an increase of flow of water in the underground workings was noticeable. The lower part of the channel, near the bend above Wolfe creek, was probably enriched by gold derived from the old channel through which the present deep channel of Antler has been cut. This old channel, which extended as a bench along the left side of Antler, crossed the site of the present stream and continued through Whiskey flat to Cunningham pass.

An especially puzzling feature in the distribution of the placer gold on Upper Antler creek is the fact that the rich pay-streak commenced abruptly near the mouth of Victoria creek and although diligent search has been made for its continuation in upper parts of the creek and its tributaries, no gold lead at all comparable to it in richness has been found. This is probably due mainly to the effects of glaciation. It will be noted from an examination of the map and will be called to mind by those who are familiar with the character of the country, that in the upland areas of Bald mountain and mount Burdett, as well as in other parts of the region, the streams head in the mountain sides in peculiarly shaped depressions, which are clearly glacial cirques formed by ice erosion. That they were formed by ice erosion and not by stream erosion is shown by the fact that streams in unglaciated regions do not form similar depressions. They are best developed on the northern slopes of the mountains because the glaciers lying on the northern slopes were protected from the heat of the sun. It is well established that a valley glacier, if it be sufficiently nourished by snowfall to render it active, will erode the bedrock of the valley in which it lies, partly by abrasion and partly by plucking out masses of the bedrock which have been loosened by frost action—the latter action taking place especially near the headwall of the cirque—and will transport the material downstream. The present small glacier in the cirque basin on the north slope of mount Agnes accomplishes practically no erosion, but there is no doubt that the small drift ridges lying in the valley below the glacier are moraines formed by this glacier at a time when it was more active than at present, and that during the Ice Age the glaciers extended far down the valleys and transported a large amount of glacial debris to lower levels. Much of the glacial drift in the valleys was probably derived in this way, and comparatively little transported by the ice-sheet which at other times during the Ice Age covered the whole area, for, as already pointed out, most of the drift in the several valleys has been locally derived. It is, therefore, improbable that any pay-streak formed in the upper parts of the valleys in pre-Glacial time could have survived the effects of glaciation, at least in those parts of the valleys where glacial erosion has been pronounced. Indeed, it is remarkable that the rich pay-streak in the shallow ground of Antler should have escaped erosion by the glaciers if it were pre-Glacial in origin.

Nugget Gulch

Nugget gulch, so named because of the numerous and occasionally large masses of galena found in the pay-gravels, flows into Antler creek in the southeastern corner of the map-area. It occupies a comparatively narrow and steep valley in the lower part and a remarkably broad and flat-bottomed valley in the upper part. A small rock canyon in which the present stream flows near its mouth has been uncovered by hydraulicking, but before mining operations were begun on the creek very few, if any, rock outcrops occurred. In its upper broad part the valley is deeply drift-filled, probably to a depth of at least 100 feet in places. The valley at its upper end is cut off abruptly by the deep and steep-sided valley of Cunningham creek. Its general appearance of being a river valley and not a valley formed by ice erosion lends colour to the belief that it is part of the ancient valley of Antler creek, formed at a time when the stream flowed at about the level of the bedrock in the drift-filled upper part, and that the higher part was captured and largely eroded away by Cunningham creek. For this reason it was regarded favourably by prospectors for many years. The elevation of the bedrock in the upper broad part is about 4,700 feet, which is about the elevation of the broad bench on the west side of Antler opposite the old town of Antler.

Considerable work was done in the early days in the shallow ground near the mouth where there were two channels, one in drift and one a narrow bedrock channel buried beneath a small thickness of drift, but the deep ground above and the difficulty of controlling the flow of ground water discouraged prospecting. It was not until 1898 that a determined effort was made to test the value of the deep ground. In this year the Bradford, Yukon, and Cariboo Gold Fields, Limited, did some tunnelling and shaft sinking. In the following year their property was taken over by the Cariboo Deeps, Limited, a syndicate of which Mr. H. E. C. Carry was manager, and further prospecting was carried on. In 1900 it was reported[1] that a channel lower than that of the present stream and a large body of pay gravel had been found. In 1906 an hydraulic plant was installed by B. A. Lasell, who had acquired the property, and water was brought on the ground by a ditch from Victoria creek. Hydraulicking was carried on each season while the water lasted, until 1913. The work is said to have paid more than expenses in some years. The hydraulic pit was extended upstream about one-quarter of a mile and in the upper part was found a deep, narrow bedrock channel running along the right side and buried beneath 50 to 100 feet of glacial clay, slum, and gravels. It was stated by Joseph House, who did the last work on the property, that when a part of this deep channel was cleaned out it was found to contain very little gold. Most of the gold was found on a rock bench on the left side which had been followed up in the hydraulicking. Apparently the narrow rock channel had been cut down to one side of the pay-streak in the valley bottom and was, therefore, nearly barren of gold. The bedrock on the bench shows no evidence of ice erosion and is considerably weathered and creviced. At the head of the pit there is a considerable body of glacial clay and stratified glacial silt, and, as the gradient in the upper part of the creek is low and the area too high to obtain a really efficient water supply, further hydraulicking is rendered difficult. A deep shaft was sunk on the flat above the hydraulic pit near the summit to determine whether the deep ground would pay to drift, but whether the bedrock channel was reached is not certain. Although the bedrock exposed in the workings shows no evidence of glacial erosion, and the presence of the narrow bedrock valley—evidently formed by stream erosion before the deposition of the glacial drift filling it—indicates that glacial erosion in the valley was not pronounced, yet the thick body of glacial drift shows that an ice-sheet once covered the valley and probably had some effect in removing or scattering the pay gravels of the ancient stream. The high altitude of the valley and its relation to the surrounding higher areas, show that it was not glaciated by a valley glacier, but was covered by an ice-sheet which must have been of wide extent. Theoretically, therefore, it might be concluded that the valley is more likely to contain pay gravels on bedrock than the upper parts of many of the creeks. Whether the gravel would pay to work could only be determined by prospecting and development work. The mining work so far done, however, does not encourage the view that a very rich pay-streak exists.

Wolfe (China) Creek

Wolfe creek, better known in recent years as China creek, flows northwest into Upper Antler, the main branch heading in the high channel parallel to and west of Antler creek.

[1]Ann. Rept., Minister of Mines, B.C., 1900, p. 734.

The bedrock valley is steeper in the lower part than in the upper, for just above Antler Creek flat the bedrock is at the surface, whereas from the results of borings it is known to be over 140 feet below the surface in Antler valley opposite the lower part of Wolfe creek. The valley is, therefore, hanging with respect to Antler creek. The creek is about $1\frac{1}{2}$ miles long and has a fall of 600 feet in this distance.

Some work was done on the creek in the early days when the shallow ground in the lower part of the creek was worked down to bedrock. Hydraulicking of the higher ground about half a mile above the mouth and 200 feet above Antler, was begun in 1901 by the Wolf Creek Mining Company, of which B. A. Lasell was manager, who had acquired two half-mile leases extending upstream from the mouth of the creek. Water was brought on the ground by a ditch from Antler creek. A No. 4 monitor was used under a head of about 250 feet. Later the ditch and sluice flume were enlarged and a second monitor and pipe-line installed. Work was continued by the company until 1912.[1] The channel—or rather a series of rock benches nearly flat in some places but irregular and hummocky in others and rising one above the other upstream—was found to be 200 to 250 feet wide. The pit was finally extended upstream for about one-quarter mile, the right rim being exposed for part of the distance. The bank, consisting of glacial clay underlain by gravels, varied in height from 40 to 80 feet. A thick body of glacial gravels partly cemented forms the left bank in the lower part of the pit. In the upper part of the pit where the last work was done, the bedrock is only about 100 feet below the ditch, so that only a small head was available for hydraulicking. Here the bedrock is soft and deeply weathered, the surface in places consisting of various coloured residual clays formed from the disintegration of the bedrock. Glacial clay quite unweathered overlies the residual clay and shows that the weathering of the bedrock must have taken place before the deposition of the clay. No gold was found on this soft bedrock, possibly because, as noted by the miners at many places in the region, such rock will not retain placer gold, that is, it does not furnish good riffles for catching and retaining the gold. It is probable, also, that the soft rock did not formerly form part of the bed of a stream, for had it done so the soft rock would have been removed by the action of the stream. The gold obtained in the workings is said to have occurred on or in the bedrock, in places where the rock was hard and creviced, and in the gravels resting on bedrock. It may be, as held by the miners, that this gold-bearing channel is an abandoned bench or old channel of Antler creek, but if so it must have been considerably eroded at a later time, for the bedrock in the channel as a whole has a steep gradient. The property had the advantages of a fair water supply and good facilities for the disposal of tailings, and is said to have yielded fair returns above expenses for several years. A run of forty to forty-five days in the spring and about the same in the autumn was usually obtained and 80,000 to 150,000 yards of dirt were moved annually. In 1915 the property was under bond to C. W. Moore, who worked it with a small force. Hydraulicking was carried on in the lower west side of the pit where a high bank of partly cemented gravels occurs, but the

[1] Ann. Repts., Minister of Mines, B.C., 1901-1912.

work did not pay and no work of importance has been done in the property since. It is interesting to note that while hydraulicking in the upper part of the pit Joseph House, foreman for B. A. Lasell, found fossil wood beneath the glacial clay. This is, so far as is known, the only occurrence in the area of fossil wood in superficial deposits older than the latest glacial deposits.

California, Stevens, and Beggs Gulches

These creeks flow into Antler creek from the northeast slope of Antler mountain. They are all characterized by steep gradients and narrow rock canyons in the lower parts and gentler gradients and broader drift-filled valleys in their upper parts. California gulch is the smallest of the three and little work has been done on it except near the mouth, where the narrow bedrock channel was mined out. Stevens gulch was mined extensively in the early days, especially near the mouth and in the middle part from $\frac{1}{2}$ to $1\frac{1}{2}$ miles above the mouth. Hydraulicking of ground that had been already drifted for a considerable distance above and below the upper cabin on the creek was carried on mainly by Chinese miners for several years prior to 1910, but the work was always handicapped by a shortage of water and by the presence of thick deposits of barren glacial clay overlying the gold-bearing gravels on bedrock. The most recent work was done about 1912 by the Bear Hydraulic Mining Company, who did considerable hydraulicking at the mouth of the creek, mainly for the purpose of constructing a dam across Antler creek and raising the water sufficiently high to turn it down Cunningham pass for hydraulicking at the Bear claim on Cunningham creek. The dam, however, was not completed.

Beggs gulch differs somewhat from Stevens and California in that there are two abrupt rises in the channel of the creek as well as the one near the mouth. About one-fourth mile up there is a small cirque-like basin some 50 feet deep into which the stream falls and about one-fourth mile higher up again the stream falls 100 feet over huge boulders. Here there is supposed to be a buried channel alongside, and a tunnel said to have been 800 feet long was run up this channel many years ago, but whether any gold was found is not known. A tunnel, known as the Pat Howley tunnel, began in the upper part of the canyon near the mouth and extended upstream about 1,100 feet. A shaft 40 feet deep was sunk at the end of it, a short distance above the middle falls[1]. One of the largest gold nuggets—17 ounces— found in Cariboo is said to have been obtained in these workings. The most recent work on the creek was done a few years ago in the rock canyon near the mouth, where an attempt was made to mine around and remove some of the huge boulders which partly block the channel, but the creek has been practically abandoned even by the Chinese for several years. Some gold was also found on Beggs gulch about $1\frac{1}{2}$ miles above the mouth where old workings exposed the bedrock at a depth of 40 to 50 feet.

Judging by the amount of mining work done on the three creeks it seems probable that considerable gold was obtained, but there is no way of telling how much or whether the work actually paid, since most of the

[1]Geol. Surv., Canada, Map 366 (1895).

work was done in the early days and there are no good records of it. The gold in all the workings seems, for the most part, to have been on or near the true bedrock, but in some of the higher workings on Stevens creek a part of the gold was on the clay which served as a false bedrock on which the gold derived from erosion of the glacial drift has been concentrated by recent stream action. A theory held for many years by some of the prospectors was that buried channels, graded to the level of Antler creek, occur near the mouths of Stevens and Beggs gulches, because the present channels are in rock, have very high gradients, and are not graded to the bottom of Antler creek. There are, however, sufficient rock outcrops along the west side of Antler valley ~~(See Figure 3)~~, to show that the existence of buried channels is doubtful, and there is also some evidence to show that the valleys are true hanging valleys with respect to Antler creek. It is evident from an inspection of the map and is obvious to one standing on the ground in the upper part of Beggs or Stevens creek above an elevation of 4,400 feet, that the valleys trend southeast in the direction of Cunningham pass. The lower steep parts bend towards the north down Antler creek. This indicates that the ancient drainage of this part of the area was down Cunningham creek, and that part of the drainage has been captured and reversed in the direction of flow by the cutting of the Antler gorge from Grouse creek up to Cunningham pass; and the hanging valleys are due to the more rapid cutting down of the main valley than of the tributary stream valleys. The Antler gorge is not post-Glacial, because glacial drift occurs in the bottom of it in places. It is probably partly Glacial and partly pre-Glacial in age. The narrowness of the gorge shows that it was formed mostly by stream erosion and not by glacial ice erosion, although the upper part was probably overdeepened by ice erosion. The narrowness of the gorge near the mouth of Beggs gulch and its greater width higher up near Cunningham also suggests that the old drainage was down Cunningham valley. It, therefore, seems reasonable to suppose that Antler creek above Wolfe creek, as well as Stevens and Beggs gulches and a stream that once flowed along Antler valley below Cunningham pass in the opposite direction to the present stream, formerly drained down Cunningham valley. Since that time parts of the valleys have been cut down 300 to 400 feet and great changes in the shapes of the valleys have taken place not only by stream erosion but by glacial erosion and deposition. One of the later changes in the drainage—not post-Glacial, however—has been the diversion of the flow of Antler from the pass known as Whiskey flat, to the present valley of the creek.

This largely theoretical discussion of the ancient drainage of Upper Antler valley has comparatively little significance regarding the occurrence of placer deposits, except to indicate that Beggs and Stevens gulches, as well as California and Wolfe creeks, occupy true hanging valleys in their lower parts and, therefore, that buried valleys graded to the bottom of Antler creek probably do not occur. It also suggests that bench deposits may occur along the east side and 300 to 400 feet above Antler creek between Cunningham pass and a point opposite the mouth of Beggs gulch. Some hydraulicking was done about 1897 near this height on Meyers creek opposite Beggs gulch and a ditch extended from the next creek above, but apparently the work did not pay. That part of the bench above the

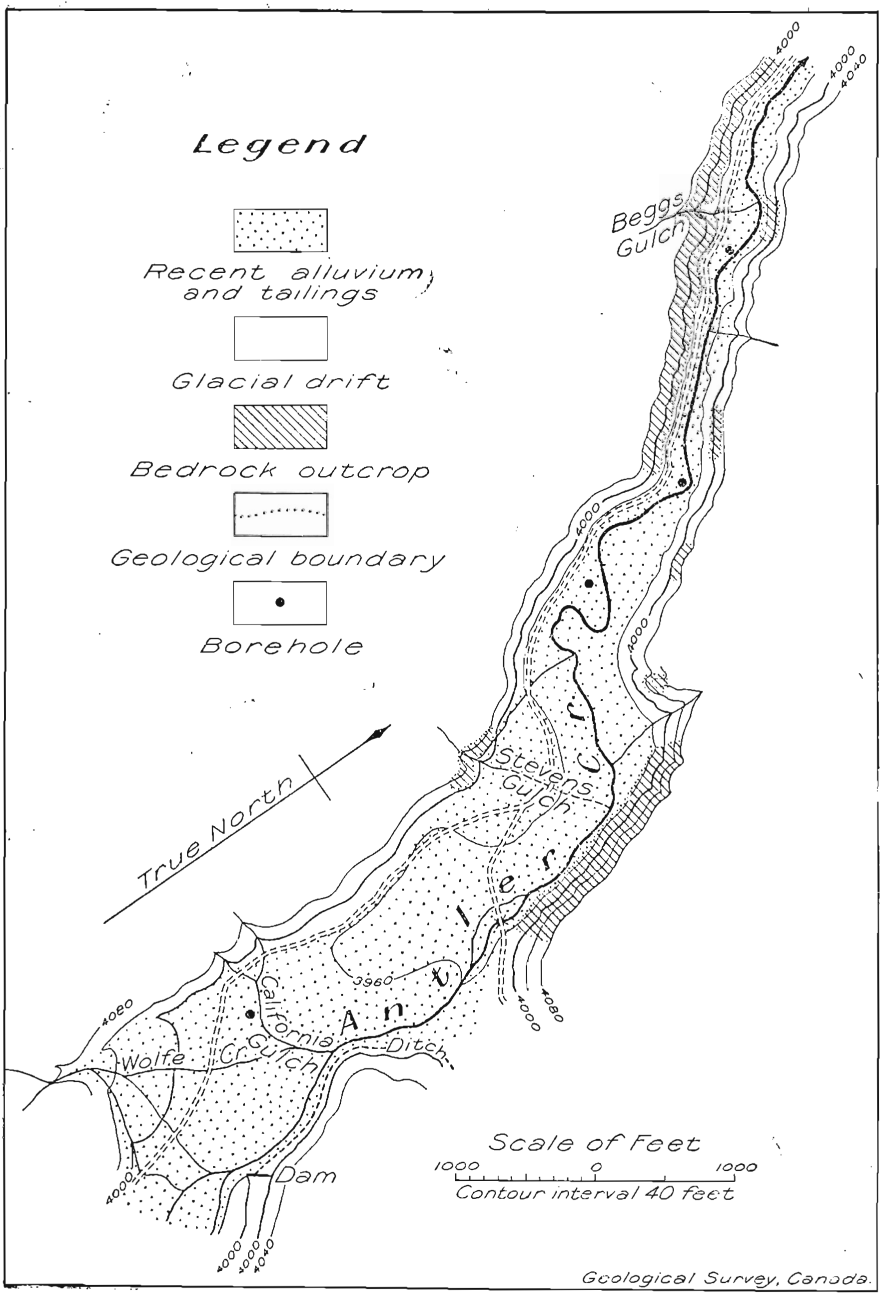

Figure 8. Part of Antler creek, Cariboo district.

western end of Cunningham pass does not appear to have been prospected. It may be, however, that the old bench deposits have been largely destroyed by the effects of glaciation.

Antler Creek between Beggs Gulch and Wolfe Creek

This part of Antler Creek valley (Figure 8) 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.

The only shaft put down in an attempt to mine the deep part of the channel gravels is the Eureka shaft about three-fourths mile below the mouth of Beggs gulch. Here the channel is very narrow and is partly blocked on the left side by a rock and earth slide from the face of the cliff. The shaft was sunk mostly in bedrock and is reported to have been 40 feet deep below the level of the creek.[1] It is stated that a drift from the bottom of the shaft was found to be too low, and that a drift at 34 feet broke into the channel. It seems unlikely that the bedrock channel is at any greater depth because of the narrowness of the valley bottom at this point. Apparently little drifting was done as there are no "headings" at the mouth of the shaft. 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 not shown in Figure 3 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, who are operating a 4-cubic foot, close-connected bucket dredge on the Nason and Lothair claims. 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

[1]Geol. Surv., Canada, Map 366 (1895).

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 have been recently put down by Mr. Thorne, Alfred Brown being the driller. Mr. Thorne states 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.

The borings in this part of Antler valley show that there is a bedrock basin in the bottom of the valley in the part opposite the mouths of Wolfe and California creeks, and that there is no outlet from the basin. Borings in Cunningham pass show that the bedrock in the channel is at least 100 feet above the level of the bedrock in the Antler channel, so that there can be no outlet in the direction of the pass, and that the bedrock in the bottom of Antler valley off the mouth of Beggs gulch is at least 15 feet higher than the bedrock in the wide part of the channel, off the mouth of Wolfe creek. The present creek has a fall of 47 feet in this distance. The presence of the rock basin in the bottom of the channel shows that the valley bottom was probably deepened in places through erosion by a small glacier that lay in the valley; the narrowness of the rock valley in the lower part, however, shows that it was formed by stream erosion. If the valley has been overdeepened in places by ice-erosion, as seems probable, there could be no preglacial gravels in the bottom of it, and, therefore, no preglacial pay-streak. The pay-streak that exists in it must be glacial or interglacial in age and, therefore, is not likely to be very rich.

Cunningham Pass

This pass (Figure 9) extends east from Antler creek opposite the mouth of Stevens creek, to Cunningham Creek valley, which drains towards the east into Swamp River valley. The pass is so low that a ditch at one time carried a part of Antler water across it for use at the Bear hydraulic on Cunningham creek. Another pass known as Whiskey flat, through which Antler creek at one time flowed, joins Cunningham pass on the south side. The only bedrock outcrop in the bottom of the valley is near the lower end at the Bear dam, where a washout exposed the rock. At this point, however, the valley is wide and it is possible that the ground is deeper beneath the drift hill on the south side. The surface deposits in the valley bottom consist in part of Recent alluvium, but are mostly glacial deposits. A small moraine occurs near the upper end where irregular basins in the drift are occupied by ponds. Morainic deposits also occur near the mouth of Ninemile creek. The valley flat has been partly formed by Recent stream and swamp deposits, but these have no great thickness. A delta in which the present stream has entrenched itself occurs at the mouth of Ninemile creek, and Cunningham Pass creek has cut a deep, narrow channel through

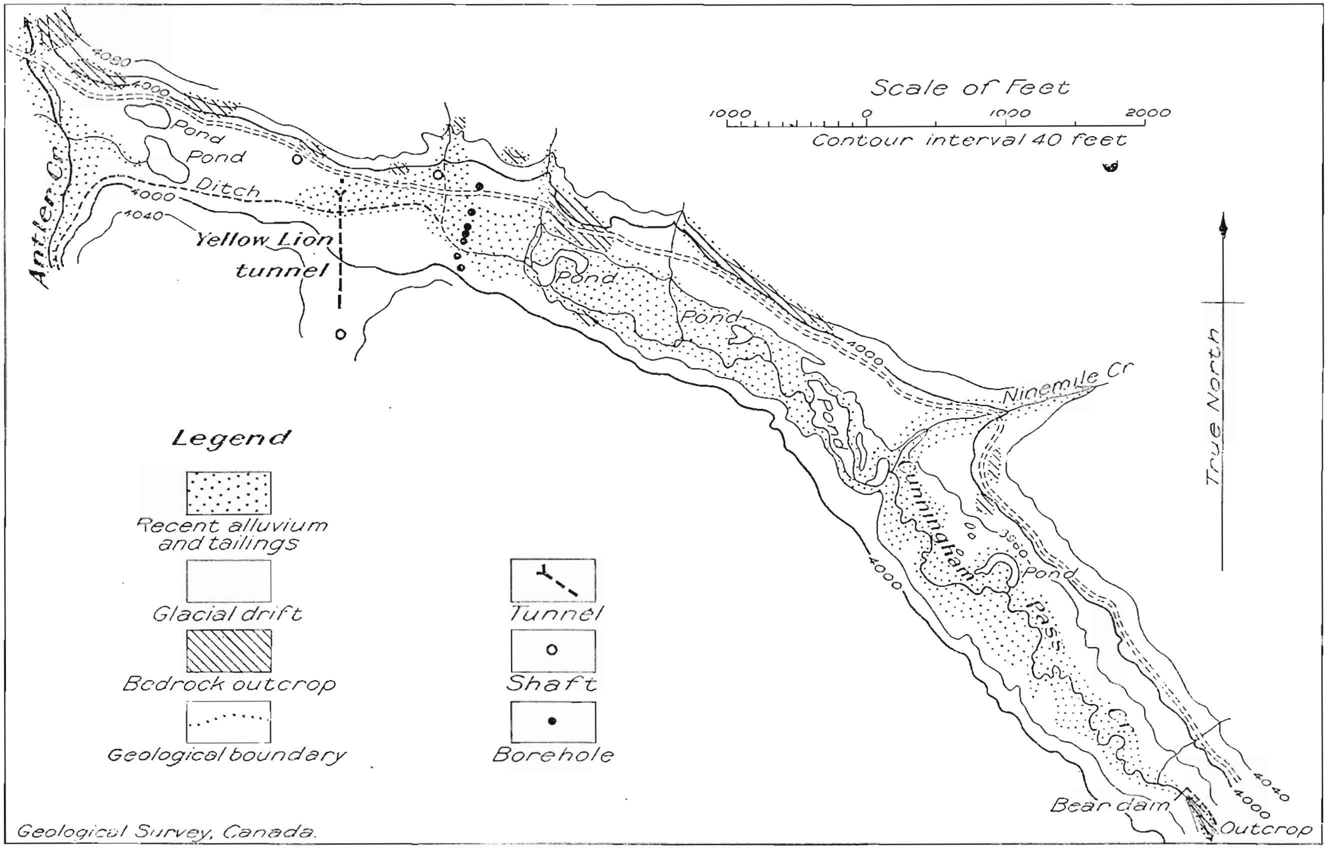

Figure 9. Cunningham pass, Cariboo district.

the drift deposits near the Bear dam. Numerous rock outcrops occur in places on the sides of the valley, but in other places the drift deposits are thick and, in the lower part, especially on the south side, are well terraced.

These terraces were probably formed by streams flowing along the sides of a valley glacier occupying the valley, for the terraces are 100 feet or more above the valley bottom and there is no evidence that the valley has been cut down to this depth in post-Glacial time. The depressions in the valley bottom occupied by ponds are partly holes from which ice blocks have melted, or are due altogether to irregular deposition of the glacial drift and they show that the valley bottom is not greatly different from what it was when the glaciers disappeared. The surface deposits in Whiskey flat have no great thickness and are mostly glacial outwash gravels deposited by a stream flowing down Antler valley and through the flat to Cunningham pass. Placer gold deposits, if present, would be expected to occur in the Recent and glacial stream deposits in the valley flat or as benches along the sides, in which cases the gold would have been derived from erosion of the glacial drift in which it has been included by the action of the glaciers. A preglacial or interglacial pay-streak might also be expected to occur in the bottom of the valley on a false bedrock of clay or on the true bedrock.

The possible occurrence of a rich pay-streak in the bottom of Cunningham pass has been a matter of speculation ever since the early days, but the ground was never tested until boring was done in 1923. Attempts were made to bottom the valley at different times, but the underground water pressure proved too great, especially as no proper pumping equipment was employed. The Black Bear shaft is reported to have been located on the south side about half-way between Whiskey flat and the mouth of Ninemile creek and to have been sunk to a considerable depth, but a search for it failed and it is stated by some of the prospectors that it was really located in Whiskey flat near the lower end and was about 45 feet deep. Another shaft was put down on the bank on the south side above the Bear dam, but it is doubtful whether it reached bedrock. The Yellow Lion Company in 1881 discovered gold on bedrock within a few feet of the surface in Whiskey flat and traced it into a channel 25 to 30 feet deep which appeared to run towards Cunningham pass.[1] A tunnel was run south from the level of Cunningham pass and a dump house built on the north side of the pass at the road, water for washing purposes having been brought by a ditch from the small stream to the east. It is stated by J. Wintrip, who worked for the Yellow Lion Company, that an upraise or incline was made from the Yellow Lion workings near the old Black Bear shaft, that the ground was worked two sets high on the west side near this shaft, and that 72 ounces in gold were taken from two sets. The bedrock is limestone and is said to be so much fractured and filled with water that the Yellow Lion Company was unable to work some of the deep ground. The property was worked for four or five years and is said to have paid well for a time, but was hampered by a lack of water for washing.

Considerable work was done in the early days near the upper end of Whiskey flat. The McBean bench on the left side overlooking Antler creek is said to have produced $30,000 from an area of 40,000 square feet,

[1] Ann. Rept., Minister of Mines, B.C., 1882, p. 356.

or 75 cents to the square foot of bedrock. A narrow bedrock channel on the opposite side of the flat at the upper end was drifted. An attempt was made by B. A. Lasell to work the ground in the upper part by hydraulicking, but it was found that, although there is an abrupt fall of about 25 feet into Antler creek, the bedrock in the channel slopes towards Cunningham pass, and that the surface deposits contain many fairly large boulders. Drilling to test the ground for dredging was done by the Yukon Gold Fields in 1915. Two cross-sections of three holes each were put down in the flat, one near the upper end and one about the middle, and showed depths of 13·5 to 38 feet. The best hole showed an average value of only 11·9 cents. Some more recent testing of the ground by trenching and rocking the bedrock gravels was done by Joseph Spratt, who dug a trench about 125 feet long, 3 to 6 feet deep, to bedrock, across the flat near the lower cabins. He secured several ounces of gold and states that the bedrock gravels average in places about one dollar and a half a yard. Apparently, therefore, the ground is very "spotted." Spratt holds that deep ground extends along the east side of the flat underneath the lower slope of the hill, and that a part of this channel has never been mined. It is not clear whether the borings established the truth of this or not, but the 38-foot bore-hole showed that the ground is much deeper in some places than in others.

Some gold was found in Cunningham pass on a rock bench on the north side between the Yellow Lion dump house and the first creek to the east, and in the upper part of the valley of this creek from 50 to 100 feet above the level of the pass. Here the gold was on the glacial clay and, therefore, must have been transported at least a short distance by the ice and reconcentrated in the surface gravels by stream action. The rock benches on the north side were also mined to some extent, but apparently no deposits of importance were found. The gold found on the rock benches was probably derived in the same way as the gold found on the clay. Judging by the character of the gold found on the upper part of the small creek and in Whiskey flat, the placer is typical glacial gravel; the pieces are mostly small, and are much flattened and worn. The gold found in the cracks and crevices in the bedrock in Whiskey flat is said to be coarser and may represent remnants of an old pay-streak.

Leases of the ground in Cunningham pass were secured in 1922 by a number of local prospectors, Alfred Brown, Joseph Spratt, S. Porteus, and others, who with commendable enterprise secured a drilling rig and proceeded to test the ground. A cross-section of seven holes was put down across the pass 950 feet east of the Yellow Lion dump house (~~Figure 4~~). The holes showed depths to bedrock of 19 feet in the hole above the road, 49, 42, 33, and 33 feet in the next four holes, and 22 and 20 in the last two, which are on a bench on the south side. The best values were found in the holes on the bench, one hole averaging 37 cents a cubic yard. Some gold was also found in the bottom $2\frac{1}{2}$ feet to $4\frac{1}{2}$ feet in the deep ground. The drilling was done by Alfred Brown, from whom the information regarding depths and values was obtained. The materials passed through on the bench on the south side are mostly gravels. On the flat there is a small thickness of surface alluvium underlain by gravels and silt. There is apparently little boulder clay, but some boulders occur. The bedrock is mostly limestone. In the autumn of 1923 drilling was continued by W. E. Thorne. Two cross-sections of bore-holes were put down, one about 700 feet east of the Yellow Lion tunnel and one 800 feet west. Both lines of bore-holes showed approximately the same depths, the bedrock channel being about 300 feet wide and having an average depth of about 45 feet, and both showed some gold. There is not sufficient evidence to determine definitely in which direction the old channel drained. The bedrock in the bottom of the valley at the Bear dam 1½ miles east is only about 5 feet lower than at the line of bore-holes first drilled. A deeper channel, however, probably occurs on the south side near the dam, for the present channel has a steep gradient at this point, and, as the valley gradually widens towards the east in the direction of the present drainage, it seems probable that the ancient drainage was also in this direction. Two shafts were also put down to test the value of the ground in the pass. One above the road and 700 feet east of the Yellow Lion washing plant was 26 feet deep, but was not to bedrock, the flow of underground water proving too great. The other is just below the road and 350 feet west of the Yellow Lion. It is 23 feet to bedrock. Joseph Spratt, who helped sink the shafts, states that good prospects of gold were found in gravel at the bottom of the first shaft and in gravel in the second shaft from the surface down to 20 feet, there being 3 feet of dry slum on the bedrock.

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 (Figure 10) 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, probably by ice-border drainage at a time when the valley was partly filled by a glacier, for the terraces occur only on one side and there is no evidence that the valley has been cut down from the level of the terraces to its present level in post-Glacial time. The rock benches, however, must have been cut before the deposition of the glacial drift which overlies them, and are, therefore, either Glacial or pre-Glacial in age. A drift ridge about 100 feet high, through which the present stream has cut a channel, extends part way across the valley on the left side near the junction. It is a morainic deposit formed partly by the Cunningham Valley glacier and partly by a smaller glacier lying in Cunningham Pass valley. The ridge must have acted as a dam for a time and caused deposition of silt in the broad part of the valley above. Some of the lower terraces cut in the drift deposits along the left bank

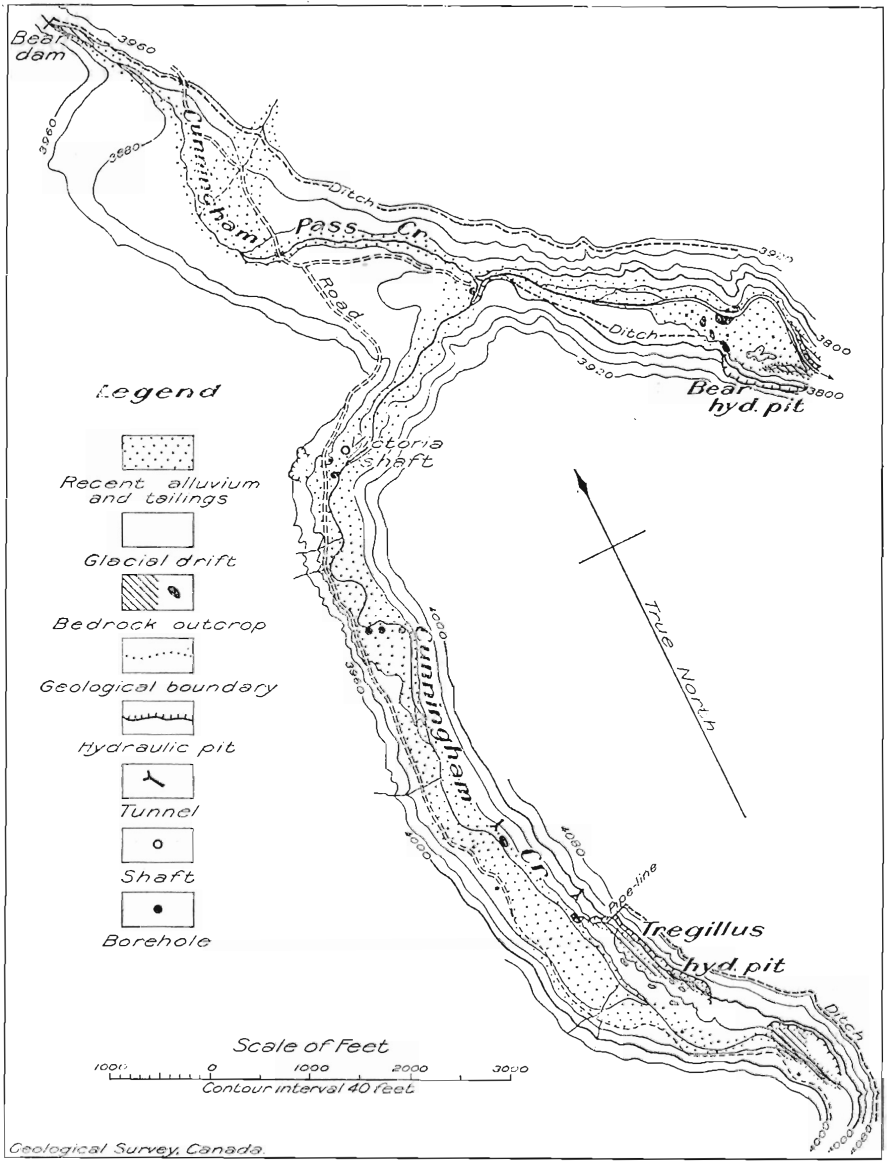

Figure 10. Part of Cunningham creek, Cariboo district.

may be associated with this damming, but the dam could not have persisted long because the materials were easily eroded. 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 ~~(Figure 10)~~ 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. They were probably formed by ice-border drainage, but may be associated to some extent with damming of the valley in the lower part by drift deposits which have been cut away by the present stream.

Placer mining on Cunningham creek was carried on in the early days mainly in the shallow ground in the comparatively narrow part of the creek. This is at and above the bend at the head of the broad and flat-bottomed part, in which part the ground is deep. It is stated[1] that shallow diggings at 8 to 10 feet were struck in 1864 on Cunningham creek and that one company was taking out 100 ounces a day, with four men; also that at the beginning of 1865 three hundred men were at work, though before the end of the season the creek was practically abandoned. Bancroft states:[2] "On Cunningham creek, a stream about 30 miles in length, a number of claims were taken up in the middle of February, 1861; and in the following year the deep diggings were prospected to some extent, but abandoned as unprofitable. In 1864 further developments were made which surprised the old miners who were acquainted with the ground. Four of the white men made a discovery near the mouth that the old bed of the creek was not beneath the present stream, but in a deep channel parallel to it, a hundred yards aside. The deeper they went into this channel the richer they found it, and in one day $460 each was obtained. The result was, that about two hundred miners located fresh claims on the creek, many of them yielding well. The excitement continued throughout 1865, and then followed another decline, the result of failure in tracing, or working, the deep lead." These statements refer to the lower part of Cunningham creek, which is not described in the present report. Practically the only published information regarding the early work on the narrow, upper part of Cunningham creek is given on Bowman's map of the creek.[3] According to this map the Discovery claim was located in 1861 by William Cunningham (after whom the creek was named), and was above the bend near where the glaciated bedrock outcrops in the bottom of the valley. It is reported[4] that a crevice (probably on or near

[1]Howey, F. W., and Scholefield, E.O.S.: British Columbia"; vol. II, pp. 118–19.
[2]Bancroft, H. H.: History of British Columbia", pp. 490–491.
[3]Geol. Surv., Canada, 1896.
[4]Dawson, G. M.: Geol. Surv., Canada, Rept. of Prog. 1876–77, p. 136.

Cunningham's claim) containing 600 ounces of gold was found. The Anderson and McDougal companies mined the shallow ground below the Discovery claim in 1862 and the Standish Company in 1862-65 hydraulicked the shallow ground just below the bend. The benches on the right side above the Standish ground were later hydraulicked chiefly by Chinese, and operations have continued nearly every season to the present time. Above Discovery claim hydraulic mining was carried on in 1876 by Palmer and Porter. Coarse gold is said to have been found mainly above Discovery claim and fine gold below. Some gold was also found at the Pierce diggings above the falls near the headwaters of the creek at an elevation of about 5,000 feet. There is no record of the amounts of gold obtained in these workings in the early days. The richest parts of the creek were the shallow ground near the Discovery and Kentucky (Sharp's) claims and a short stretch above Palmer's hydraulic one-half mile higher up. Between the two places there is a depression in the bedrock and the channel is deeper than above or below. It was not mined in the early days or was found to contain insufficient gold to pay. The most important work on the upper part of the creek since the early days was an attempt to mine this deep part. The work was carried on from 1901 to 1905 by Messrs. McGregor, Thompson, and Ross. The bedrock which outcrops on the discovery claim, in the bottom of the valley on the left side, dips downward upstream and under the creek towards the right bank. The ground was prospected by a shaft 20 feet deep and one drift of 115 feet with an incline down to the west for 75 feet and another to the east for 35 feet, but the deepest part of the channel, which was supposed to be under the hill on the east side, was not reached. From this work $2,500 in gold was obtained.[1] A bedrock cut 1,100 feet long and having a gradient of only 2 inches in 12 feet was then made below the deep ground, with a view to obtaining an outlet low enough to enable the ground to be worked by hydraulicking. It was later found to be necessary to extend the rock cut 125 feet in order to reach the basin. Water was finally turned on in May, 1905, and a month's run obtained. It was then seen that the ground was too deep to be bottomed by the cut. A shaft 17 feet deep was sunk in the pit and three drives run, which showed the ground to have a maximum depth of 32 feet. The gravel taken out in the drives was measured and was found to carry values of $2.18 a cubic yard. Values on bedrock were "spotted" and were estimated to be about the same as in the bedrock gravels.[2] It was then proposed to install an hydraulic elevator, but no further work was done and since that time the upper part of the creek has been practically abandoned.

The lower deep part of the creek from the bend down to the junction with Cunningham Pass creek is of interest at the present time chiefly because borings have been made recently 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 ~~(Figure 10)~~. The Victoria shaft is said to have been 120 feet

[1] Ann. Rept., Minister of Mines, B.C., 1902, p. 94.
[2] Ann. Rept., Minister of Mines, B.C., 1905, p. 57.

deep to bedrock[1] and was probably a "gravel" shaft throughout. Some of the prospectors, however, state that the shaft was about 100 feet deep, and a boring recently made near the shaft shows that the ground is probably not over 100 feet deep. Mining was carried on for several years prior to 1877. It is stated that the channel was drifted across and a raise of 60 feet made on the far side, and a drive run upstream on bedrock for 500 feet. In 1877 the company, after expending some $30,000, took their pumps out of the shaft and abandoned the ground, having thoroughly tested the channel, but without finding ground to pay.[2] The bedrock gravels are said to have averaged about one dollar a cubic yard. Considerable mining by hydraulicking and ground-sluicing has been done on the high bank above the Victoria shaft, the gold being found in the surface gravels resting on glacial clay. A shaft sunk in the pit is said to have shown some gold in gravels beneath the glacial clay, but apparently not in sufficient quantity to pay, as no further work was done. The surface gravels in the valley bottom along the creek from above the Victoria shaft down to the junction were extensively mined in the early days by wing-damming of the creek and by ground-sluicing, the gold occurring in the surface gravels and at their base on the glacial clay.

In 1922, five bore-holes, the locations of which are shown on Figure 10, 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 ~~(Figure~~ 10) 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, and is held by F. J. Tregillus, Joseph House, and F. W. Reed. 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 by Messrs. Tregillus, House, and Reed and operations begun at the lower end of the old pit in May, 1923. The mine was operated by two men, Messrs. House and Reed, and cleanups of 70 ounces made on July 9 and 15 ounces on August 10 after a run of about forty-five days. The gold has an assay value of $17.89. The amount of ground moved was determined by the present writer by measuring the pit and assuming that the original surface had the same surface slope as the adjacent ground at the head of the pit. This assumption is probably nearly correct, for the surface slope along the side of the valley is nearly uniform for a considerable distance. The length of the cut was 110 feet and the amount of ground moved, that is gravel in place, was 5,700 cubic yards, the average value being 27 cents a cubic yard.

[1]Geol. Surv., Canada, Map 368 (1895).
[2]Ann. Rept., Minister of Mines, B.C., 1877, p. 397.

The rock bench in the pit is about 40 feet above the level of the creek and slopes gently downstream. The deposits overlying the bedrock vary from 4 to 5 feet at the outer edge of the bench to about 30 feet at the inner end and consist of 4 to 10 feet of surface gravels underlain by boulder clay and glacial gravels. The clay is red in some places and blue in other places where it is compact and has not been oxidized by the ground waters. Hard masses occasionally occur and numerous boulders are present which, however, as a rule, are small enough to be handled by the derrick with which the mine is equipped. 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. It is not what is usually described by the miners as "lead" gold, which is well worn, but not pounded or flattened, coarse gold mixed with fine. Many of the pieces are flattened and much worn and there is considerable fine gold, but practically no flour or fine scale gold, so that the gold is readily saved in a short length of sluice boxes. There is some evidence that another rock bench occurs just above the bench exposed in the pit and that it carries some gold, but sufficient work has not been done to definitely determine this question. A tunnel run into the bank about 250 feet down-stream from the lower end of the pit and about 50 feet above the creek showed some gold. Another tunnel, 1,100 feet farther down, also showed some values in the bench deposits a few feet above the creek level. It, therefore, seems probable that the bench deposits continue for a considerable distance down-stream on the right side. The work done in 1923 would indicate that the gold production of the bench amounts to about $1,400 per 100 feet in length, but this amount may be considerably increased if higher benches carrying gold are found. Moreover, very much higher values amounting to nearly $2 a cubic yard are reported[1] to have been obtained by the Sam Wah Company in hydraulicking in 1902 on the upstream continuation of the bench, so that it is reasonable to suppose that rich spots also occur lower down. The difficulty of estimating the value of a property of this character, even after considerable development and mining work has been done, is thus well illustrated. The property has the advantages of good facilities for the disposal of tailings and a fair water supply. Sufficient water for a No. 2 monitor with a 3-inch nozzle was available in 1923, the head being 132 feet. The ditch is about 3¾ miles long and consists of an upper part about 2 miles long from which the water drops about 50 feet to the lower ditch 1¾ miles long. Normally there is a large supply of water in Cunningham creek even in dry seasons, but in August, 1923, the flow at the head of the ditch was insufficient for hydraulicking. The ditch carries about 300 miner's inches of water and is of high gradient. A much larger supply of water can be made available by a good ditch.

[1]Ann. Rept., Minister of Mines, B.C., 1902, p. 95.

The Bear hydraulic mine ~~(Figure 10)~~ is located on the right limit of Cunningham valley half a mile below the junction, and was operated on a fairly large scale for several years. The valley bottom at this point is about 800 feet wide, but immediately below it narrows, and the stream has a high gradient, rapids and falls extending downstream for about 4 miles. In the hydraulic pit near the lower end there is a small bedrock basin into which a channel was cut in order to bring the sluice boxes up on bedrock. The right bank of the pit consists of glacial gravels, silt, and clay about 100 feet thick. Near the head of the pit the bedrock rises rapidly and forms part of the right bank. On the valley flat near the cabins and for some distance upstream on the right side the bedrock is nearly at the surface. The left bank is composed mostly of glacial drift, but at one place bedrock outcrops in the bed of the present stream. There is no direct evidence of a buried rock channel lower than that of the present stream.

The first hydraulicking on the Bear claim was done about 1897 by the Menominee and Marinette Company who, after hydraulicking a part of one season with a small water supply from Cunningham creek, and not being able to make the work pay dividends from the start, as had been anticipated by the shareholders, discontinued operations[1]. In 1902 the property was purchased from Messrs. Fry and Johnston by B. A. Lasell and Joseph Wendle, and the ground was prospected by means of a small hydraulic plant. In the spring of 1903 a moderately large hydraulic plant was installed and a ditch dug from Antler creek down Cunningham pass. The ditch extends along the left side of the valley and at the lower end opposite the claim is 200 feet above the bottom of the pit. Hydraulicking started on August 15 and continued until October 12. Work was continued in 1904 and 1905. A bedrock cut about 700 feet long, said to have cost $14,000, was made into a rock depression which proved to be a pot-hole or irregular depression in the old channel and to contain little gold. The ditch from Antler was enlarged to a capacity of 3,000 miner's inches and a dam started near the lower end of Cunningham pass 1 mile above the junction. The dam was constructed by hydraulicking the material from the bank to make a fill, water being supplied by a ditch from Ninemile creek. A ditch from Cunningham was also in use to supply water for a ground-sluice. Mr. Wendle, the manager, states that in the first season's work the comparatively small amount of material worked averaged about 35 cents a yard, in the second season about 40,000 yards were handled, which averaged between 16 and 17 cents a yard; in the third season slide rock was encountered over the gravel and so much barren overburden had to be handled that there was no profit. About $30,000 was spent in development and equipment. The gold occurred in the gravels, especially in the lower part immediately above the bedrock and on the bedrock, and was mostly fairly fine "flaxseed" gold. In 1906 the dam was completed, prospect shafts were sunk, and the bedrock cut, which was nearly 20 feet deep in the deepest part, extended farther upstream into the bedrock depression, but little actual mining was done. In the spring of 1907 the dam burst and the company was forced to shut down. The dam, however, was repaired and hydraulicking resumed in the spring of 1908, but the results

[1] Ann. Rept., Minister of Mines, B.C., 1903, p. 59.

par 4

not being satisfactory mining operations were suspended. The mine was equipped with an overhead cableway operated by waterpower for handling the boulders; 1,300 feet of 20-inch pipe-line carried the water across the creek from the ditch to the pit and a No. 6 monitor under a head of about 200 feet was used[1]. In 1922 a lease of the ground was granted to Dave Bever, who is mining the shallow ground near the cabins by ground-sluicing. Water is supplied by a ditch leading from Cunningham creek just below the junction, the fall of the creek in this distance being 60 feet and the flat on the south side of the creek being 15 to 20 feet above the creek. The ground is only 3 to 6 feet deep on the flat near the cabins and for some distance upstream, and the Recent gravels resting on bedrock as well as the glacial gravels in the benches above the creek carry some gold and are easily mined.

The distribution of the placer gold on upper Cunningham creek, as shown by the mining operations, was erratic and the absence of a rich pay-streak throughout the greater part of the bedrock channel in the valley bottom was, without much doubt, due to the effects of glaciation. The occurrence of crevices in the glaciated bedrock at Cunningham "bar," containing large quantities of placer gold, is one of the most remarkable in the district. It would seem to show that a rich pay-streak formerly existed on or near bedrock in the valley bottom and that the glacier which moved down the valley partly destroyed the pay-streak but did not erode the bedrock to a sufficient depth, at this place, to remove the gold which had been concentrated in the crevices. Certainly the placer gold must have been released by weathering from the parent rock and concentrated in the valley bottom before the glaciers appeared. It is conceivable that the gold was transported a short distance downstream by the ice or by streams issuing from the ice and was concentrated in the crevices at the time of occupancy by the ice or after its retreat, but this seems improbable because the gold is said to have been too coarse and nuggety to have been transported by the stream and because a thin layer of cemented sand and silt partly covers the surface of the bedrock, in places nearly closing the upper parts of the crevices. The depression in the bedrock in the valley bottom above the "bar" was probably the result of glacial erosion and, therefore, contained no rich pay-streak, although, as would be expected, the glacial and post-glacial gravels filling it contain some gold. The occurrence of gold in the gravels overlying the glacial clay in the lower part of the creek near the junction shows that some of the gold was transported by the ice and included in the glacial drift, because the concentrations of gold in these surface gravels was the result of erosion of the glacial drift and not of the bedrock. The gold must, therefore, have been included in the drift. It is possible that a small part of it was derived from erosion of the bedrock by the glaciers, but the greater part was probably derived from the old concentrations in the valley bottoms. The great width of the valley bottom in the part below the bend down to the junction, and its lower gradient, suggest that this part was glacially eroded and overdeepened and that, therefore, a rich pay-streak would not be expected to occur in the valley bottom. The rock benches along the

[1]Ann. Repts., Minister of Mines, B.C., 1904–1908.

right limit near the upper end of this broad part, however, show n evidences of glacial erosion, and appear to represent parts of the old creek bottom formed at a time when the creek flowed at a considerably higher level. It is at least evident that they were formed by stream erosion before the deposition of the glacial drift that overlies them. They, therefore, form the most promising placer ground on the creek. The main bench crosses to the left side above the bend and agrees fairly well in elevation with Cunningham "bar." How far downstream these benches extend, or whether they cross to the other side lower down is not known because they are concealed beneath glacial drift. They slope downstream, in the parts where they have been exposed in mining operations, at a rate greater than that of the surface of the valley flat. It is held by some of the prospectors that the benches extend along the right limit all the way down to the Bear claim, or at least that the old stream channel was in that direction. At the Bear claim, however, the old channel worked was about at the level of the present stream channel and the presence of rock benches beneath the high gravel bank on the right limit was not proved. The deep ground in the main valley from the Bear dam down to the Bear claim has been tested only by the boring at the junction. The low values obtained here and the great width of the valley bottom—suggesting that the effects of glaciation were pronounced—discourage the view that a rich undiscovered pay-streak exists, although it cannot be said that the possibilities of this part of the valley have been exhausted.

Cunningham creek was especially affected by valley glaciation, because it heads in one of the highest parts of the plateau region and flows north. The narrow, rich pay-streak, mined in the early days in the upper part of the creek, may have escaped erosion by the glacier on account of the narrowness of the valley bottom, or it may have been produced by glacial and post-glacial streams which concentrated gold that had been derived from placers eroded and transported a short distance by the glacier. This part of the creek has been regarded for many years as being practically worked out, although occasional finds of small areas of workable ground, especially on the high bank on the left side above Cunningham's claim, have been made even in recent years, but none of these has proved of sufficient value to warrant the installation of a mining plant.

Grouse Creek

Grouse creek, the lower part of which is shown on Figure 11, 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 $1\frac{1}{2}$ 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. Opposite the lower part of the high bank, thinly drift-covered rock benches occur and a broad, gravelly flat extends north to the head of Canadian creek. 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

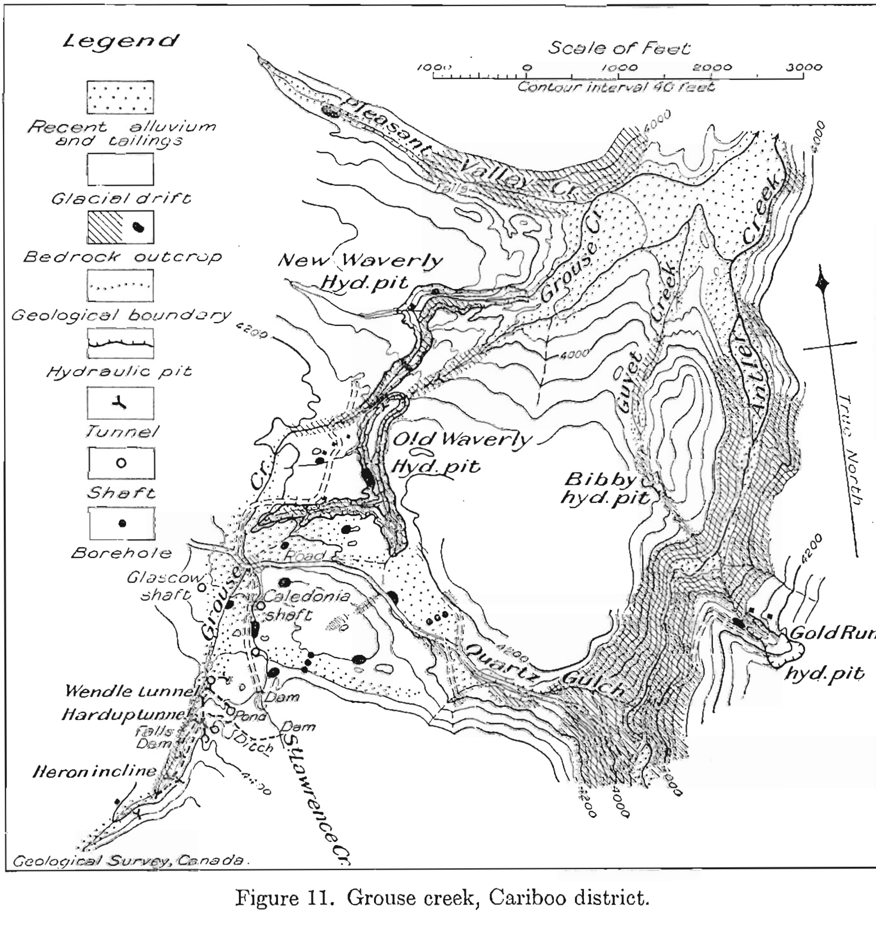

Figure 11. Grouse creek, Cariboo district.

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 ground along Grouse creek from the head of the pits up to the falls on Grouse creek averages only about 8 or 10 feet in depth and there is an abrupt fall into the old cross-channel known as the Waverly channel. Quartz gulch flows east from the flat at the head of the Waverly pit and occupies a very steep rock gorge in its lower part where it joins Antler creek. The valley of Antler creek from Quartz gulch down nearly to the junction of Grouse creek is a steep-sided rock canyon over 200 feet deep. Bedrock outcrops in the bottom of it a short distance below the mouth of Quartz gulch and for 1½ miles downstream the valley flat averages only about 100 feet in width. In the lower part the flat widens and near the mouth of Grouse creek is 300 to 400 feet wide. A broad flat covered with tailings occupies the lower part of Grouse Creek valley for nearly a mile up from the mouth. The lower part of Pleasant valley at its junction with the Grouse Creek flat is a narrow rock canyon, the old channel apparently being buried under drift on the south side. St. Lawrence creek coming from the south joins Grouse creek at the road above the Waverly pits. It formerly flowed, in its lower part, east down a drift-filled valley to Quartz gulch. This valley lies between a rock hill thinly veneered with drift, on the north side, and a steep slope with bedrock outcropping in places, on the south side; and in its upper part is only a few feet above the level of Grouse creek. Borings in the valley bottom near the upper end show the ground to be 30 feet deep. Borings in the flat along the old Waverly channel, extending from the head of the pit to the head of Grouse creek, show the ground to have a maximum depth of about 80 feet.

Gold was discovered on Grouse creek in 1861. The Discovery claim, as shown by Bowman's map of Grouse creek, was below the bend and about half a mile above the Heron claim—which later became the most famous ground on the creek. "Grouse creek was mined to a limited extent in 1861–62 and then abandoned until 1864, when the Heron claim was located on it. After an expenditure of $150,000 the Heron claim yielded $300,000. Under the supposition that the ground was worked out, it was then sold for $4,000; but on cutting an outlet 18 inches deeper the claim continued to yield from 80 to 100 ounces a week throughout the ensuing season. The creek was again abandoned until 1866 when the lead was rediscovered; and the Heron, Discovery, and other claims yielded from $15,000 to $20,000 to the share, raising the creek to the dignity of one of the principal mining fields in Cariboo for the ensuing season. In 1867, thirty-five mining companies were at work; a sawmill was in operation, and two respectable villages sprang up in the valley. The Heron Company, in March, 1867, paid a dividend of $800 to the share and the Full Rig Company a dividend of $200 for a week's work. These companies worked out the lead for 1,000 feet on the channel; above and below them it could not be found. In May, 1867, the Black Hawk and Canadian companies were seeking it by a tunnel and incline. The Water Witch Company sank a shaft near the middle of the creek, and drifted into deep ground, causing an excitement, but it proved to be only an undulation like that in the Hard-up Company's tunnel."[1] The Black Hawk claim was just above the Heron ground, and the Full Rig just below Discovery claim. Above Discovery were the James Tunnel,

[1] Bancroft, H. H.: "History of British Columbia", pp. 493–494.

French Company, Ne'er-do-Well, and Carnelian claims and at the bend the Cascade, Shy Robin, and Ontario. Above the bend on the right bank was the Duxeford shaft where the old channel was considerably above the present creek, and at Boone Sawmill point one-fourth mile above the bend, where a buried channel occurs on the right side, the gold lead practically ended. The present channel of the creek opposite Boone Sawmill point and for some distance above was mined to bedrock by a Chinese company, but the work is said not to have paid. The highly productive part of the creek extended upstream from the Heron ground about $1\frac{1}{2}$ miles, and was mostly worked out in the early days. The old gold-bearing channel near its upper end is about 40 feet above the level of the present creek; it crosses over and forms a rock-bench on the left side at the bend and again crosses to the right side below the bend, on which side it continues as a rock-bench downstream to a short distance above the Heron ground, where it coincides with the present creek. In the Heron ground it is below the creek-level and under the high bank on the right side. Thus the gradient of the old channel is greater than that of the present. Rock-benches, however, occur on the left side opposite the Heron ground and represent a still older channel with a low gradient. The benches are evidently a continuation of those farther upstream and the deep channel in the Heron ground is, therefore, more recent than the channel represented by the rock-benches, and the present channel is still more recent. The richest parts were where the present channel has cut through the old channel or lies close alongside of it. The principal work done on the upper part of the creek since the early days was on the Hard-up ground, immediately below the Heron ground. This work and the work on the Heron ground are here described somewhat fully because they have a bearing on the question of the continuation of the famous "Heron lead" into the drift-covered flats in the lower part of the creek. The continuation of this "lead" has been searched for for many years and the question of its occurrence is still an open one. The information regarding the workings was obtained mainly from Joseph Wendle who, along with B.A. Lasell, had an interest in the Hard-up property, and was for several years in charge of work by the United Company. Parts of the workings which have not caved were also examined. The location of the tunnels and a generalized plan of the workings on a small scale are shown on Figure 11.

The Heron Company's ground consisted of nine 100-foot claims and extended upstream on the right side from where the present stream falls about 6 feet over a hard limestone ledge. The Hard-up Company's ground was immediately below and extended downstream on the right side for about 800 feet, the lower part of the ground being on the flats. Bedrock outcrops in the bed of the creek from the falls upstream for 725 feet to a point 185 feet upstream from the Heron incline, which extends into the right bank from near the level of the creek and from which most of the pay-streak mined in the buried channel beneath the right bank of the creek on the Heron ground was taken out and washed. The incline was about 100 feet long, and the bottom of the channel was about 18 feet below creek-level. The present stream flows in a narrow rock channel, which is apparently partly an artificial cutting for 350 feet from a point 185 feet above the Heron incline. This cutting is probably the one referred to above as having been made in 1867. For some distance above the upper end of it, the old channel practically coincides with the present channel and here the ground was mined out from the surface down to bedrock. A tunnel or incline known as the Jimmie Allen tunnel was also run into the old channel at the creek-level at a point about 250 feet below the Heron incline. It is marked by an old log shack. Allen was foreman for the Heron Company and is said to have mined $750,000 in gold from 400 feet of the old channel. The rock channel was so narrow and steep-sided that an 8-foot cap reached from one rim to the other. The gold occurred on a "hard-pan" layer about 18 inches above bedrock and some sets are said to have produced as much as 500 ounces. Although these reported yields are possibly exaggerated it seems probable that the channel was one of the richest—if not the richest—for its size ever found in Cariboo. A tunnel which runs into the bank a few feet vertically above the Heron incline is known as the Ralph tunnel. It is open for about 150 feet, and was run about twenty years ago for the purpose of determining whether a channel higher than Heron channel existed beneath the high clay bank on the hill-side, but apparently no channel was found.

About 500 feet upstream from the Heron incline two tunnels were run into the right bank. One, known as Gad's tunnel, is mostly in bedrock and ended in bedrock, and was run on the supposition that the bedrock was rimrock and that by cutting through it a channel would be found. The other, which is nearer the creek level and about 150 feet upstream, is known as the Jarvis tunnel or Jarvis "pot-hole" and was run by Jarvis, McAlinden, and Company, in 1898. A depression in the bedrock about 30 by 24 feet was found, the bottom of it being at about the level of the creek and the ground about 20 feet deep. The small depression was mined by drifting and produced about $4,000 in gold.[1] The gold is said to have been partly distributed through the gravel filling the depression and was partly on bedrock in the bottom. Similar occurrences are very rare in the district, most of the pot-holes or irregular depressions in the bedrock being barren of gold. It is not clear whether the depression is a true pot-hole formed by stream erosion or an irregular depression formed by glacial erosion, but it is probably the former. In either case the deposition of gold in it was evidently due to its proximity to a gold-bearing stream channel and to the fact that the channel shifted and deposition took the place of erosion. The mining work showed pretty definitely that a rich buried channel existed under the bank on the right side of the creek on the Heron ground and that there was no higher channel on that side of the creek. The Heron channel is said to have been mined out down to a point 96 feet above the Hard-up line where there was a steep gradient in the channel and the ground was difficult to mine because of the presence of water and slum and because the drifts were being extended downstream.

Mining on the Hard-up ground was carried on in the early days and from 1902 to 1905 by the United Mining Company, who held the Hard-up real estate claim and a lease of the ground above. The old Hard-up tunnel is 200 feet below the falls and runs into the right bank from near the creek level for 110 feet to a working chamber, where a blind shaft was sunk 18 feet to bedrock. The company had a water-wheel on the creek and hoisted

[1] Ann. Rept., Minister of Mines, B.C., 1899, p. 274.

the pay gravel into the working chamber and transported it thence to the creek for washing. The working chamber is in hard glacial gravels and clay and is still intact. The new company extended the Hard-up tunnel to a total length of about 480 feet and made an upraise for an air-shaft at the end of it. At 190 feet from the portal a blind shaft was sunk 11 feet to bedrock. At 150 feet a branch tunnel was run directly upstream for 100 feet and thence away from the creek and under the high bank for about 500 feet, there being a rise of about 60 feet at the end. At the bend a drive was also made upstream towards the old Heron workings and about 50 feet from the bend an upraise of 80 feet to the surface was made for an air-shaft. These tunnels and prospect shafts and drives were made in search of the Heron lead. It was held that since there is a 7 per cent grade in the old channel from the lower part of the Heron ground into the Hard-up ground and as the pay found on the Hard-up was much less than on the Heron, there must be a higher channel. It was finally determined, however, that there was only the one channel, and that it was not very well defined. The old driftings on the Hard-up extended upstream and downstream from their hoisting shaft, but were mainly downstream. The new company drifted the channel for a width of 30 feet in places and upstream to a point 60 feet below the old Heron workings. Rod-holes were made into the old workings and caused an inrush of water and slum, which flooded the workings. A tunnel referred to as the Wendle tunnel was then run from a point, at the creek level, 250 feet downstream from the old tunnel, but it was not low enough to reach the bottom of the channel, and a blind shaft was sunk to the level of the old workings. The driftings were carried downstream about 150 feet from the old Hard-up hoisting shaft. At the lower end the bedrock was found to be very soft and to be pitching downstream. An incline was run down the slope for about 30 feet, but the soft bedrock caused caving and the work was abandoned. The best pay found by the new company was about 30 ounces to the set, but the average was very much less. The gold was practically all in crevices in the bedrock. At places where the bedrock was soft and where the channel was narrow there was no gold. At one place the channel was only 4 feet wide and the bedrock smooth limestone.

Another tunnel known as the Frenchmen tunnel runs into the right bank from the creek-level, 100 feet downstream from the Wendle tunnel. It is about 450 feet long and ends beneath a small pond. Its course for most of the distance is shown by cavings at the surface. It is said to have been on bedrock for a considerable part of its length, but to have passed over undulations in the bedrock. Apparently no pay was found. There is an old shaft in the bed of the present creek just below the Frenchmen tunnel. It is said to have been 18 feet deep to bedrock and is probably the Water Witch shaft (page 82). Another tunnel was run into the low hill on the right side 200 feet below the Frenchmen tunnel, but nothing is known regarding its extent or the results of the work.

The Glascow shaft (Figure 11) is said to have been 34 feet deep, but little seems to be definitely known regarding its exact depth or the results of the work. A shaft referred to by some of the prospectors as the Caledonia shaft, although it is not on the Caledonia ground, is located alongside

St. Lawrence creek 400 feet above the junction with Grouse creek. It is 24 feet deep, but may originally have been somewhat deeper. In addition to these shafts a considerable number of prospect pits were sunk at fairly close intervals all the way across the Grouse Creek and St. Lawrence Creek flats above the main highway. It is stated that the prospect pits showed the bedrock to be within 6 to 10 feet of the surface except in a few places, and no continuation of the old channel was found. The somewhat deeper ground at the Glascow and Caledonia shafts shows either that there are bedrock depressions at these points or that there are one or more buried channels. The work on the Hard-up ground, however, definitely showed that there were irregular depressions or undulations in the bedrock, which were probably due to glacial erosion, and that, although the Heron channel extended into the Hard-up ground it was there very largely eroded away. The results of prospecting in the creek flat down to the road apparently did not indicate the presence of any rich pay channel. It, therefore, seems probable, if the Heron channel originally extended down through the flat, that it has been largely eroded away at least as far downstream as the road. It is possible, also, that it was gold-bearing in some places and not in others. Whether it extended farther downstream and joined the Waverly channel is another question. It is shown on Bowman's map of Grouse creek as extending down to and through the Waverly workings in the lower part of Grouse creek. These workings are herein described somewhat fully, because of this question of the continuation of the Heron channel, and because hydraulic mining, on a fairly large scale, has been carried on at the Waverly mine for many years. The question of the future possibilities of this mine is also an important one.

The Waverly deep channel was discovered in 1867 by sinking shafts. The Princess Marie shaft, one of the first to be sunk, was located near the upper end of the old Waverly hydraulic pit, nearly opposite the mouth of the draw known as Carey's draw, which extends west from the pit for about 1,500 feet and is an artificial cutting. The Talisman shaft was near the lower end of the pit, and the Lady of the Lake about midway. The prospectors happened to be reading Waverley novels at the time, hence the names of the shafts. The Princess Marie shaft was about 120 feet deep. Two companies, the Princess Marie and Talisman, mined the ground for a time by drifting, but experienced considerable difficulty in handling the water. To overcome this difficulty a bedrock tunnel 500 feet long was run through the rimrock below the Talisman shaft. A ridge of hard rock crosses the channel about 200 feet above the lower end of the old pit and there is said to be a drop of 12 feet in the old channel at this point. The upper end of the bedrock tunnel where it entered the channel is apparently at a lower level than the bedrock above the falls, but a few feet higher than the bedrock below the falls, although the exact depth to bedrock in the lower part of the pit is not known. In the drifting operations it is stated that the pay gravels were dumped down the slope at the falls and thence trammed out through the tunnel to dump boxes for washing, the drainage water from the undergound workings being used for washing purposes. The workings caved at one time and a small pond in a depression at the surface drained into them. The accident happened at a time when all the miners were out of the workings and there was no loss of life, although considerable damage was done and caused a suspension of mining operations for a time. A mine car is said to have been shot out through the tunnel on to the dump by the sudden rush of water and mud. The workings, however, were cleaned out and drifting resumed, but the work is said not to have paid. In 1879 the Waverly Hydraulic Mining Company was formed to mine the ground by hydraulicking. An attempt was made to reach the deep channel by bringing a cut up in the first draw north of that in which the tunnel is located, but this failed as it was found that the bedrock in the draw was too high and it was held by some of the miners that the old channel was a "blind channel", which ended near the Talisman shaft. An open-cut was then made down to the upper end of the bedrock tunnel and hydraulicking started by sluicing the material out through the tunnel, the upper part of it being enlarged somewhat and the bottom raised sufficiently to provide grade for the sluice boxes. Hydraulicking in the old Waverly pit was continued each season, while the water lasted, from 1884 to 1914. Water was brought on the ground by ditches and flumes from the dam on Grouse creek above the falls. John Pomeroy was manager until 1905 and was succeeded by Pat Carey. Approximately 750,000 cubic yards of dirt were washed and the total output of gold—as stated by the late James Bibby, who kept the books of the company for many years—was about $75,000, or an average of 10 cents a yard. It is stated that a cleanup on bedrock was made for the first time in 1896 and that no pay gravels were found until the face had been carried about 1,000 feet along the pit, when pay gravel 80 feet wide and 25 feet deep above the boxes came in.[1] With the advance of the face of the pit, the pay gravels and bedrock were found to become lower, until in 1908 the gravels dipped below the grade of the sluice boxes. This low grade of the bedrock continued with the advance of the face until after several years operations it was found necessary to use an hydraulic elevator to reach them. When operations ceased in 1914 the deep channel was about 20 feet below the upper end of the sluice boxes.

The New Waverly Hydraulic Mining Company, Limited, organized in 1918 by J. G. McLaren and C. W. Moore, 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 were moved by hydraulicking only a few ounces of gold were 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. Two bore-holes 55 and 41 feet deep, respectively, were put down to bedrock in the draw

[1]Ann. Rept., Minister of Mines, B.C., 1897, p. 494.

500 feet below the tunnel and showed no gold. 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. There appears to be no channel of Grouse creek graded to the bottom of the Waverly channel, unless it be in the meadows near the head of Quartz gulch. 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, which is too low for hydraulicking. The ground beyond the head of the pit, however, may be proved to be of some value for dredging or by hydraulicking from Quartz gulch, as one of the bore-holes in the cross-section showed values of 10 or 11 cents a yard. This raised hopes that better values would be found on the west side of the channel, but the cross-section of holes was not completed. 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. There is a difference in elevation of about 125 feet below the lower end of the sluice boxes in the new pit and of the bedrock near the head of the old pit, a distance of nearly 3,600 feet. There is, therefore, an average grade of about 5 inches (to the 12-foot box), which is sufficient for hydraulicking. As mentioned above, however, there is said to be a 12-foot fall over a hard rock ridge near the lower end of the old pit and there may be abrupt rises at other places. Consequently, even if the lower part of the channel were thoroughly cleaned out, it is likely that the bedrock would be lost in places in extending the sluice boxes upstream.

In 1922 drilling was done, on the recommendation of the present writer, 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. Drilling at this place was recommended because it appeared to be the only place where the ground across the valley of Grouse creek on the flats had not been thoroughly tested in the search for the continuation of the rich channel on Heron ground above. A cross-section of six bore-holes was put down by C. W. Moore 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) was 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. The discovery was made by Dave Bever, caretaker at the mine, and several ounces of gold were recovered by ground-sluicing and by shovelling into sluice boxes. 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 deposits overlying the bedrock in the lower part of Grouse creek, so far as seen in the sections exposed, are all glacial, consisting of sands, gravels, glacial silt, and boulder clay. In many places at the base of the deposits there are large broken and crumpled masses which were evidently torn from the bedrock by the glacier and there are many depressions in the bedrock itself formed by ice erosion. The gold recently discovered occurs on a hard layer of stony clay 1 or 2 feet above the bedrock. The pay was overlain by a few feet of sands and gravels and may extend for some distance upstream, but is not in a definite rock channel. It is probable that the lack of continuation across the Grouse Creek flats of the rich pay-streak in the Heron ground above was due to the effects of glacial erosion and possibly also to there having been several rock channels on the flats, the stream shifting from one to the other and scattering the gold.

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.

Lower Antler Creek

Lower Antler creek (Figure 12) below the mouth of Grouse creek flows northeast in a broad, flat-bottomed, and drift-filled valley for 1½ miles or nearly to the mouth of Cariboo creek, a large stream coming from the east. A short distance above the mouth of Cariboo creek there are two small rock canyons through which Antler creek flows and bedrock is exposed in the bottom of the creek in one of them, and along the west bank for some distance upstream. From Cariboo creek down to Russian creek, fairly wide alluvial flats and comparatively narrow rock canyons alternate along the creek. Empire creek, a fairly large steep creek coming from Waverley mountain on the west, enters about half-way down. For 1½ miles down stream from the mouth of Russian creek the Antler flows in a narrow rock canyon 100 to 150 feet deep. Below the canyon the main valley widens greatly and the stream flows for several miles in a narrow, deep valley cut in drift and bordered by terraces. The river banks gradually lower and for several miles above the junction with Bear river at the foot of Bowron (Bear) lake the stream flows in a broad, flat-bottomed valley along which terraces cut in drift occur at various elevations up to 100 feet or more above the valley flat. Antler creek at the mouth of Russian creek is a fairly large stream about 30 feet wide and 2 to 3 feet deep even in the dry season; during the freshet it is a rushing torrent, as the gradient in the narrow parts is fairly steep. In the upper flat part below Grouse creek the fall is only about 40 feet in 1½ miles.

Mining was carried on for many years along the benches on Antler creek, especially along the west side for some distance above and below

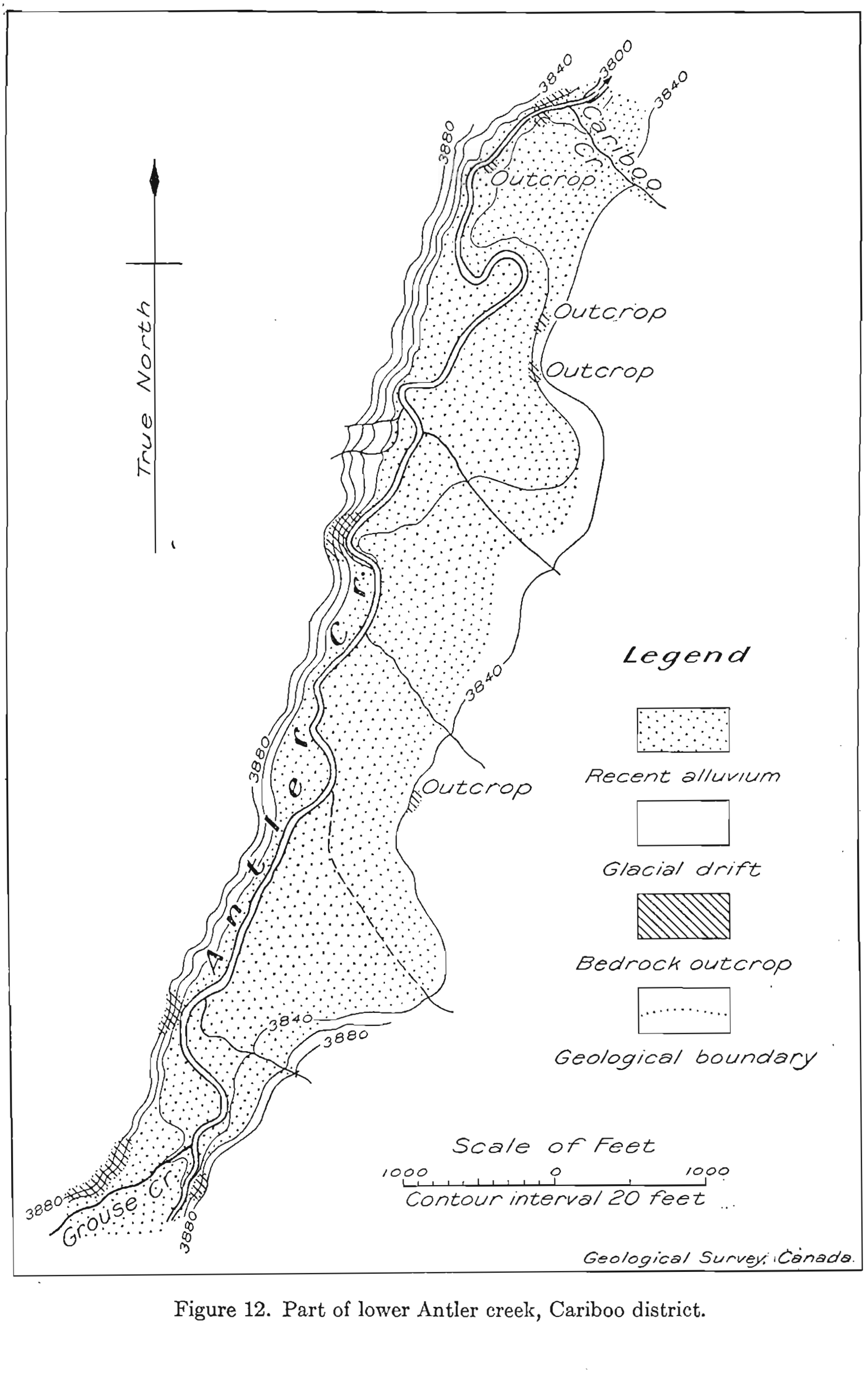

Figure 12. Part of lower Antler creek, Cariboo district.

the mouth of Empire creek and at the mouth of Russian creek. Two hydraulic plants were operated for one or two seasons on benches at the mouth of Russian creek, but the operations did not pay. The gold was fairly fine and not easily saved in hydraulicking and was confined to a thin pay-streak in the surface gravels. Conditions were nearly similar along the benches near Empire creek where, although good wages are said to have been made by individual miners in the early days, attempts to mine the thin pay-streak on a fairly large scale failed. None of the tributary creeks along this stretch of Antler creek proved gold-bearing except near their mouths, and there the pay was in surface gravels on the benches of Antler creek. The best values were apparently found in places where the gravels overlay rough bedrock, and in a few places where the gravels are underlain by boulder clay. There is little doubt, therefore, that the gold was transported by ice or by streams from the upper parts of the creek and was concentrated along the benches by stream erosion of the drift. The chief interest in the creek at the present time is the prospective value as dredging ground of the stretch for 1 or 2 miles downstream from the canyon above the mouth of Grouse creek (*See* Figures 11 and 12). Coarse gold is known to have been found on Guyet creek and on Grouse creek, tributary to Antler creek near the upper end of the proposed dredging ground, and some coarse gold is said to have been found on Guyet creek nearly down to Antler Creek flats. As the gold on the creek is probably transported gold it is possible that a pay-streak occurs in places on bedrock, especially if, as seems probable, the deposits in the valley bottom consist entirely of gravels, for fairly coarse gold would tend to work down through the gravels and become concentrated on bedrock. On the other hand, it may be overdeepened in places by ice erosion, and if so no very rich pay-streak is likely to occur.

Guyet or Gold Run

Guyet (or Gold Run) channel (Figure 11) is on the southeast side of the canyon of Antler creek, a short distance below the mouth of Quartz gulch. An old stream channel, which has been exposed by hydraulicking, trends southeast and has a comparatively low gradient. Its apparent continuation is seen on the opposite side of Antler creek at the head of Guyet creek. The part between has been destroyed by the cutting of the rock canyon of Antler creek over 200 feet deep. The deposits filling the channel in the hydraulic pit consist of a few feet of gravels at the bottom, overlain by stratified glacial silt and clay about 50 feet thick, glacial sands and gravels 45 feet thick, and 50 feet of boulder clay at the top, the total thickness being about 160 feet.

Mining on a small scale near the mouth of the channel where it drops off steeply into Antler Creek canyon was carried on for about sixteen years prior to 1897 by a Frenchman named Guyet who also did considerable mining on Guyet creek, which is apparently a continuation of the channel and was named after him. In 1899 the claim was acquired by the Cariboo Consolidated Mining Company and prospecting of the ground was done under the direction of Joseph Wendle, who later purchased the claim and holds it at present. A tunnel 104 feet long was run into the bank and the channel crosscut. Mr. Wendle states that there was as much as 14 feet of gravels in the channel which is 60 feet wide, and that they showed values of about 75 cents a cubic yard, and that there were small values in the glacial gravels above. In 1908 and 1909 a ditch 4 miles long from Cariboo creek, one of the best water rights in the district, was constructed and in 1910 hydraulicking was carried on by W. F. Gore, who purchased the property from Mr. Wendle. About $700 in gold is said to have been recovered, but only a small amount of ground was moved. In 1912 the mine was operated by Messrs. Meyers, Hazlett, and Taylor, apparently with poor results, and since that time the property has lain idle. The main ditch is nearly 500 feet above the bottom of the pit, but does not extend to the head of the pit. The water flows down to a lower ditch from which a pipe-line extends to the pit, furnishing a head of about 275 feet. The ditch is still in good condition except for a few hundred feet near the upper end where it is cut in gravels and where slides have occurred. There are splendid facilities for disposal of the tailings and a large supply of water can be made available. The main difficulties in the way of successful operation of the mine are the great thickness of the material filling the channel, the occurrence of boulder clay at the top which renders it dangerous to place a monitor close to the face in the pit, and the low average gold values in the deposits.

Carey Creek

Carey creek—which is named after Pat Carey who did considerable mining and prospecting work on Grouse creek and vicinity—lies between Canadian and Grouse creeks and flows into Pleasant Valley creek. The only work done on the creek was at the mouth, where a tunnel was run upstream about 60 feet and a shaft 33 feet deep sunk near the end of the tunnel. The shaft was not sunk to bedrock as a strong flow of water was met with in the bottom. Some gold was found on bedrock in the tunnel near the mouth, but none in the shaft. The work was done about 1914 by Pat Carey, Bob Buchanan, and Harold Mason.

Canadian Creek

Canadian creek (Figure 13) is a short creek between French and Grouse creeks and flows northeast into Pleasant Valley creek. One branch heads on the northeast slope of mount Proserpine; the branch coming from the southeast heads near some small ponds on Grouse Creek flats, which are also in part drained by another stream, flowing into Pleasant Valley creek. There is a rock ridge 300 feet high lying between the creeks, so that the valley of Canadian creek is bounded by rock rims. The valley bottom, however, is broad and is for the most part drift-filled to a considerable depth. In the lower part, at a point 3,000 feet up from the junction with Pleasant Valley creek, there is a marked increase in the grade of the creek. The steep gradient continues for 1,300 feet, in which distance the creek has a total fall of 100 feet and flows for part of the distance over bedrock. There is a high bank of boulder clay on the west side of the creek along the steepest

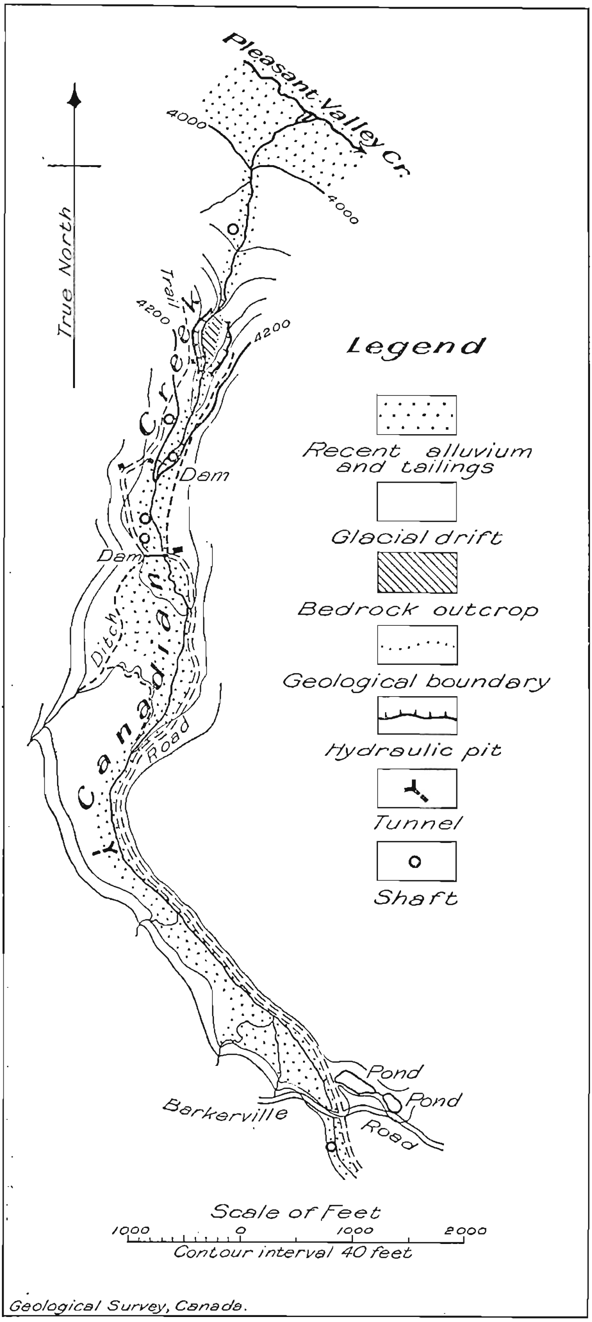

Figure 13. Canadian creek, Cariboo district.

part and beneath the bank there is a buried channel somewhat deeper than the present channel. There may be also a buried channel on the east side. An unusual feature of the creek is that, as exposed in the old hydraulic pit, there are large, irregular masses of hard calcareous tufa or limestone resting on the true bedrock and intermingled with the bedrock gravels. The limestone contains numerous impressions of wood and is probably post-Glacial in age, but may be Pleistocene. It has been formed by the deposition of lime from water flowing beneath the surface and down the valley of the creek. Limestone beds in place occur higher up in Grouse Creek valley and form a possible source of the lime. Deposition from the ground water was probably caused by the marked change in the grade of the creek, which permitted release of pressure and aeration of the water—for the deposits are near the surface—a process which is known to cause deposition of lime from water heavily charged with it. Seasonal changes in temperature of the water may also have had something to do with deposition of the lime, for it is more soluble in cold water than in warm water. The lower part of the creek for 1,500 feet above the junction with Pleasant Valley creek has a low gradient, but the valley is drift-filled and the bedrock gradient may be nearly as great as in the steep part of the creek. The sudden change in grade of the bedrock channel of the creek—for it, as well as the present channel, is not evenly graded—may indicate ice erosion of the bedrock in the upper part of the creek, because the steep part does not appear to be due to exceptional hardness of the rock. As an alternative explanation, it may be that Pleasant valley was deepened, at some point, faster than Canadian.

Mining on the creek by drifting was carried on by the Clear Grit Company for over twenty years prior to 1892. The shaft is located 100 feet below the lower small flush dam and is said to have been 60 or 70 feet deep. In 1892 it was reported that another channel 40 feet west of the one that was being mined had been discovered, and a shaft was sunk on the hill on the west side of the creek 350 feet below the Clear Grit shaft, for the purpose of mining the channel. The shaft was equipped with a steam pump and was sunk partly in bedrock. Judging by the mine dump, some drifting was done from the bottom of the shaft, but the work was continued only for a short time. In 1899 the Slocan Cariboo Mining and Development Company, of which H. T. Windt was manager, secured two leases on the creek and purchased the Clear Grit (Crown-granted) claim. They later acquired another lease and the Miller (Crown-granted) claim below the Clear Grit ground. In 1900 hydraulicking was begun and was continued for three or four seasons. A recovery of 38½ ounces of gold in 1902 was reported.[1] Water was obtained by a short ditch from the dam in the wide, upper part of the creek and only a small supply under a head of about 100 feet was available at the hydraulic pit. In 1902 an additional supply was obtained from Grouse creek, which, however, was not sufficient to permit of hydraulicking throughout the dry season. A cut about 300 feet long and 5 to 15 feet deep was made in the bedrock in the lower part of the hydraulic pit and into the bank of boulder clay and gravels 40 to 80 feet

[1]Ann. Rept., Minister of Mines, B.C., 1902, p. 118.

high on the west side of the pit, but the deep channel was not reached. An attempt was then made to extend the pit upstream along the bedrock bench toward the Clear Grit ground, but the numerous glacial drift boulders and large masses of limestone on the bedrock, as well as the small water supply, proved serious difficulties. In 1904 a tunnel was run for about 300 feet from near the head of the hydraulic pit towards the Clear Grit ground, but apparently no good pay was found and the work was not continued. Some prospecting was also done from the Miller shaft, 83 feet deep, below the Clear Grit ground. In 1905 and 1906 the company, then under the management of H. McMasters, attempted to sink a shaft in the flat above the Clear Grit ground and below the upper dam for the purpose of mining the deep channel by drifting, but failed in their attempts because of the underground pressure of water and mud. In 1908, the property being held by Alfred Ansley as trustee, another shaft 200 feet farther downstream was sunk about 80 feet to bedrock and drift mining, under the management of H. H. Jones, was carried on for one or two seasons. It is stated by Dave Bever, who worked in the mine, that there was an incline of 12 feet from the bottom of the shaft up to the driftings and that workmen at the face were always in danger of being trapped if the pumps failed. Two steam pumps were used and there was no difficulty in controlling the flow of water when the pumps were working properly. A great deal of time was lost as the boilers were defective and the water frequently gained on the pumps. A 6-foot drive with 9-foot caps was run upstream, but no great amount of drifting was done and the operations are said not to have paid.

There is an old tunnel on the west side of the creek about 1,600 feet down from the Grouse Creek road. It has a fair-sized dump at its mouth and was apparently run in search of the channel of the west branch of the creek, but nothing is known regarding the results of the work. A housed-in shaft with pumping machinery installed, on the west side of the valley just above the Grouse Creek road, was sunk by the old Dominion Company and is said to be 60 feet deep. The ground at the shaft is said to contain some gold all the way to bedrock and the average values at the bottom are reported as 1½ ounces to the set, but only prospecting work was done. In 1900 the Cariboo Deeps Company Limited, under the management of H. E. C. Carry, installed machinery at the shaft with the intention of pumping it out and testing the ground, but no actual work was done.

The ground on Canadian creek has been pretty thoroughly tested and no very rich pay-streak was found. The results of the operations of the Clear Grit Company, which were the most extensive, are not definitely known. The mining is said to have paid considerably more than expenses in some years, but probably on the whole was done at only a small profit. There is some possibility that the ground in the upper part of the creek and in Grouse Creek flats at the head of the creek will prove of value for dredging, which is probably the only way in which it can be mined. The grade is too low for hydraulicking and apparently the ground is not rich enough to pay for drifting. There is also some possibility that a buried gold-bearing channel occurs near Grouse Creek road at the foot of the draw in the mountain slope in which the main west branch of the creek heads.

French Creek

French creek (Figure 14) 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. Practically no work has been done on the creek in recent years. 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

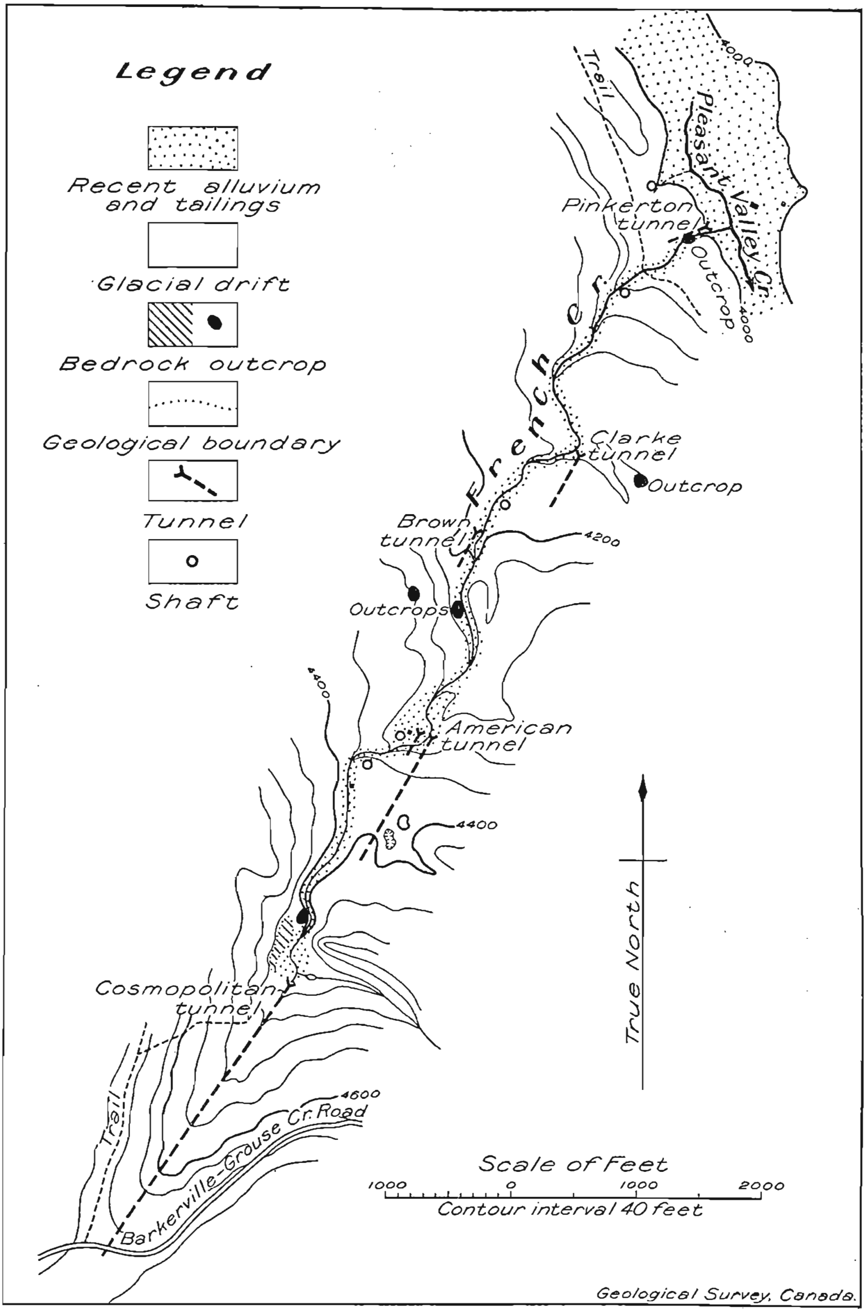

Figure 14. French creek, Cariboo district.

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. There would be a difficulty, however, in disposing of the tailings in that a "ranch" is located in Pleasant valley opposite the mouth of the creek.

Conklin Gulch

Conklin gulch (Figure 15) 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

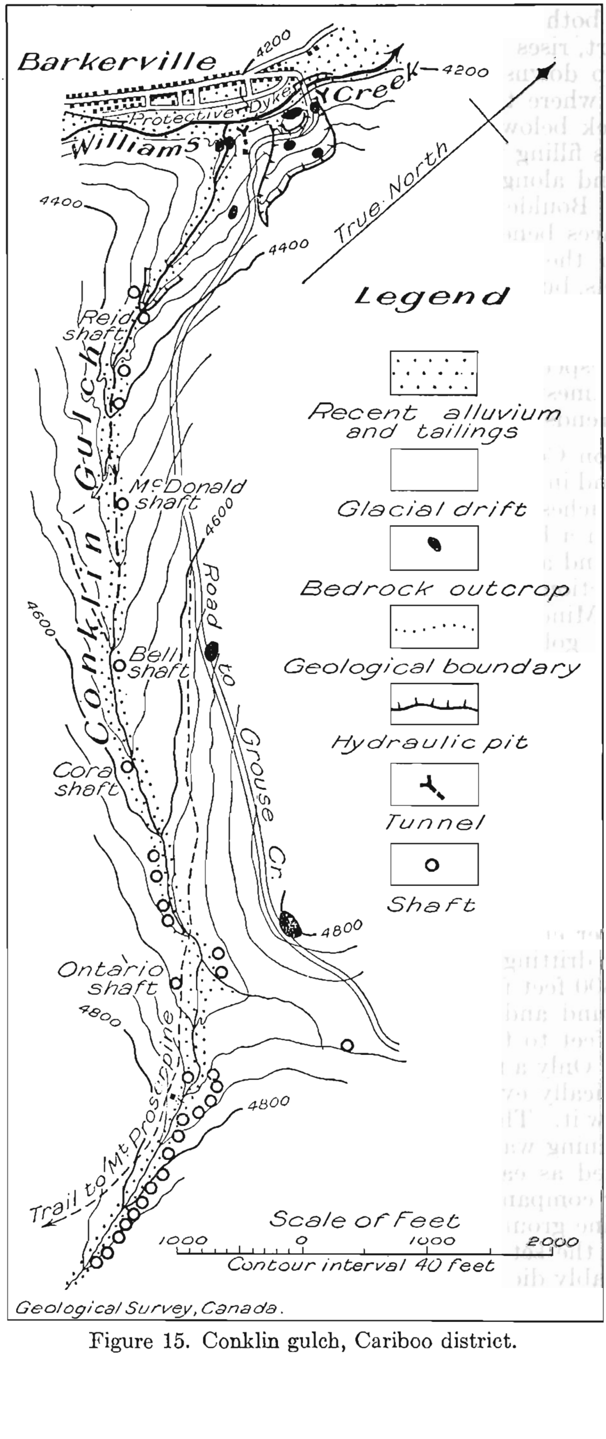

Figure 15. Conklin gulch, Cariboo district.

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. Falls or steep downstream slopes in the beds of the old channels rarely occur except where the streams join the main valleys, but one occurs on Williams creek below Black Jack canyon and there are probably others. 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. The creek was noted for the "bad ground" encountered in drifting, and because of the presence of water and "slum" great difficulty was experienced in running tunnels and especially in making upraises along the sides. There are a great many limestone boulders in the valley, apparently because a limestone band trends in the direction of the creek.

Mining on Conklin gulch began a year or two after the discovery of the rich ground in the lower part of Williams creek, and continued for many years. The richest claims were near the mouth of the creek and included the Aurora on a bench on the right side and the Ericsson and Sawmill in the deep ground alongside. These three claims, according to the estimate of the production of Williams creek given in the Annual Report of the Minister of Mines, B.C., for 1896, are credited with a production of \$1,500,000 in gold, and the total production of the creek is given as \$2,265,000. Considerable information regarding the old workings on the creek is given on Bowman's map of Williams creek.[1] The Conklin Gulch Company, formed in the seventies, held the ground in the lower part of the creek—including the Sawmill and Ericsson claims—and carried on mining work for nearly twenty years both by drifting and by hydraulicking on a small scale. An hydraulic cut was carried upstream 1,400 feet from the mouth, but the bedrock was not reached and work was discontinued about 1890. The Aurora group of claims was opened as an hydraulic in 1881 and hydraulicking was continued for several years. There is a long stretch on the creek from near the upper end of the old hydraulic pit to near the upper end of the Cora Company's ground, which is said not to have paid for drifting. The Cora Company's ground extended downstream for about 1,800 feet from the Proserpine trail crossing. Below it was the Renfrew ground and above it the Ontario Company's ground extending about 1,400 feet to the White Pine ground in the narrow part above the summit flat. Only a few of the old shafts are shown on Figure 15. There is a shaft practically every 100 feet on the White Pine ground and for some distance below it. The old claims were only 100 feet long and here evidently individual mining was practiced to an extreme, in spite of the fact that it was recognized as early as 1862 that in mining the deep ground it was necessary for companies to be formed in order to make the work pay. On the White Pine ground the pay was said to have been as high in places as 50 ounces to the set. It was only about one set wide, however, and the average probably did not exceed 30 ounces, so that each claim could hardly

[1] Geol. Surv., Canada, Map 364 (1895).

have produced more than $15,000. As the ground was 20 to 50 feet deep and even 60 feet in places in the lower part, shaft sinking and draining of the ground must have proved expensive, and it is doubtful whether the operations actually paid. The Ontario group of claims are said to have produced $54,000 in gold from the upper 500 feet of the channel. In the lower part a short distance above the trail crossing there is said to be a fall of 30 or 40 feet in the bedrock channel. On the Cora the pay is said to have been found mainly on the benches. The bedrock in the deep channel is reported to have been very irregular and rich spots were found only in a few places. The most recent work on the creek is that by Jack Bell, Bob Buchanan, and other local miners, who sank a shaft 41 feet deep on the upper part of the Renfrew ground below the Cora in the hope of finding a part of the channel that had not been mined, but without success. About seventeen shafts and prospect pits were also sunk by Sandy McDonald on the benches along the south side of the creek from the mouth up. They are reported to have yielded good prospects, but not sufficient to pay for drifting.

The ground on the creek is held under three leases by John Hopp, who proposes to mine it on a large scale by hydraulicking. 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 2,000 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. If Williams creek is to be dredged the dredging will have to be done and the town of Barkerville moved before hydraulicking of Conklin gulch is begun, because hydraulicking would result in a much greater accumulation of tailings in Williams creek than there is at present. The present tailings have been derived from hydraulicking in Black Jack cut and in Stouts gulch and are said to average 25 feet in thickness. The thickness in the part above the mouth of Conklin gulch and below the Black Jack canyon, judging by old photographs of the creek and its present appearance, must be nearly 50 feet. 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. As an alternative, only the water from the Gold Fields ditch leading to Stouts gulch from the upper part of Lightning creek and from Groundhog lake, with the water from the upper part of Williams creek, may be used. The ground on the creek is generally considered to be the most favourable ground in the area for hydraulic mining on a large scale if sufficient water for the purpose can be made available at a reasonable cost.

Walker Creek

Walker creek flows into Williams creek at the abandoned town of Richfield. Hydraulic mining on the creek near the head of the old workings has been done on a small scale during the past few years by George Moore, Joel Stevens, and the Houser brothers. Although only a small amount of ground has been mined, owing to the small supply of water available, considerable gold has been recovered, in spite of the fact that part of the ground has been pretty thoroughly drifted. Water is obtained from the Gold Fields ditch at times when the water is not being used at Lowhee mine, and a small supply is available from the creek itself. The work has shown that bedrock benches occur along the creek and that gold occurs on them or in the glacial gravels covering them. One bench has been exposed by hydraulicking just below the old dam, but its full width has not been determined. There may be other benches above and higher up the creek and the discovery raises the question whether there may not be sufficient ground on the creek or above and below it on the west side of Williams Creek valley to pay for hydraulicking on a fairly large scale, although the area has generally been considered as pretty well prospected and the rich pay-streaks mined out.

Lowhee Creek

Lowhee creek was discovered to be gold-bearing by Richard Willoughby in 1861 and was named by him in honour of the "Great Lowhee," a secret society among the early miners at Yale, B.C. The upper part of the creek above the head of the hydraulic pit, where mining is being carried on, and the upper part of Stouts gulch, are shown on Figure 16. The creek is about $1\frac{1}{2}$ 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. Watsons 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. The occurrence is an unusual one and is difficult to explain. Weathering of the rock at or near the surface is the most reasonable explanation, but no weathering could have taken place since the deposition of the glacial drift in the valley, for the materials immediately above the rock are quite fresh and unweathered. On the other hand, if the weathering has taken place before the deposition of the glacial drift, it is difficult to understand how it was that the stream in cutting down its valley did not entirely remove the soft clay. Slow percolation of water along the bedrock in the bottom of the valley—for the stream has a fairly high gradient—during Pleistocene and Recent times, although there could have been little underground flow of water during the times of occupancy of the region by the ice-sheet and valley glaciers, may have caused disintegration of the rock.

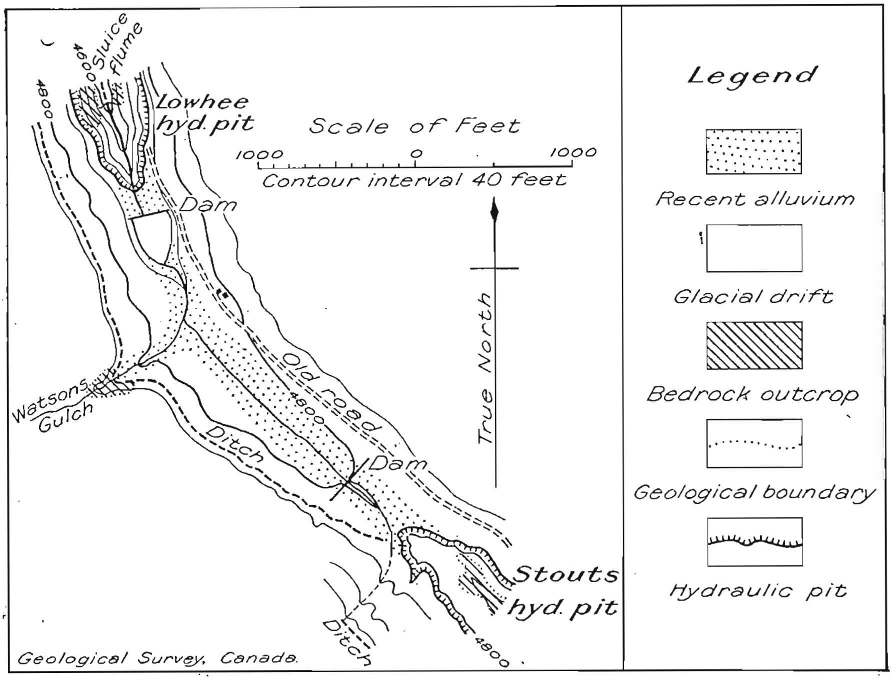

Figure 16. Stouts-Lowhee divide, Cariboo district.

If so it would be expected that the bedrock would be disintegrated generally in the old buried channels of high gradient streams, but this is not the case. There is a barrier of hard rock across the valley below the occurrence and the rock above is soft and easily disintegrated. It may be that the residual clay in the stream bed is all that remains of a deeply weathered zone formed preglacially and mostly cut away by stream erosion. There are numerous angular fragments and large blocks of bedrock (slide rock) in the bottom of the channel, which evidently slid in from the sides of the channel before it was filled with glacial drift and are, therefore, preglacial or interglacial in age. There is no evidence that the bedrock valley was formed after a first advance and retreat of the ice, and the hanging character of the valley at its mouth with respect to the main valley shows that it was formed before the main valley was deepened to its present extent. If the valley had been formed at the same time as the deep part of the main valley it would have been graded to the bottom of the main valley. The slide rock in the bottom of the valley is, therefore, probably preglacial, as well as the placer gold which occurs mainly in the bedrock gravels and in crevices and depressions in the bedrock. Part of the gold, however, may have been deposited along with the glacial gravels which extend nearly down to bedrock, and afterwards have been concentrated in the bed of the channel. There is said to be a pay-streak also in the drift some distance above the bedrock. This pay-streak may be interglacial in age and may be the result of stream erosion of the glacial drift and concentration of the gold in it. Practically all the materials overlying the bedrock, as exposed in the sections at the head of the hydraulic pit, are clearly glacial in origin. They consist mainly of poorly stratified gravels, interbedded in places with thin layers of silt (slum). Near the top on the sides, the valley filling is boulder clay which in most places is only a few feet thick. The top few feet in the central part consist of Recent alluvial deposits of sand, fine gravel, and muck. The materials filling the valley are, therefore, easily hydraulicked out, the main difficulty being that there are numerous large boulders near the base of the deposits which require blasting before they can be put through the sluice boxes.

The broad, drift-filled channel extending from the head of Stouts gulch to the head of Lowhee creek is a unique feature in the district and has been generally regarded as evidence of an old high-level stream channel coming from the upper part of Williams creek or from the upper part of Conklin gulch[1]. Hydraulicking in Stouts gulch was carried over the summit as far as grade could be obtained and some gold was found in the channel on the summit. It is uncertain whether the gold occurred on bedrock or was derived from the glacial drift filling the channel, for in hydraulicking it is frequently difficult to tell just where the gold is coming from. The valley filling near the summit is mostly boulder clay, but some gravels occur and there is a small thickness of alluvium at the top. The bedrock where exposed by hydraulicking shows no evidence of glacial erosion, but it is so soft that evidences of glacial erosion would not have been preserved. The broad, flat-bottomed character of the channel, however, and the occurrence of boulder clay extending down in places to bedrock, suggest glacial ice erosion of the bedrock to some extent. Judging from the topography it is quite possible that a branch of the Williams Creek glacier passed over the summit and widened and deepened it to some extent. It is probable that the ancient valleys of Stouts gulch and Lowhee creek headed close together. It may be that the summit channel represents all that is left of the channel of an ancient stream flowing at the level of the pass, but it seems more probable that the channel was partly formed by glacial erosion and also represents the divide at the headwaters of the two streams, Stouts and Lowhee.

Placer mining on Lowhee creek (Figure 16) 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

[1]Tyrrell, J. B.: "Notes on the Placer Mines of Cariboo, British Columbia"; Econ. Geol., vol. XIV, p. 339 (1919).

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. The drifts were three or four sets wide in some places and in others, where the channel is very narrow, only one set wide, and many raises were made on the sides. Hydraulicking began in the nineties and since that time nearly 8,000 feet of the channel has been completely hydraulicked out. Hydraulicking 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, under the efficient local management of Laurent Muller, 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, which is about 4,200 feet long, were replaced by steel plates. The last of the steel plates were put in in August, 1924. In hydraulicking out the channel bottom to permit of lowering of the grade of the sluice boxes, which were in part a few feet above bedrock, considerable amounts of very coarse gold were recovered, showing how difficult it is to recover all the gold in hydraulicking, unless the solid bedrock is reached. The sluice boxes at the upper end are about 2 feet in the bedrock, and there is little doubt that the bedrock will be held in extending the pit upstream. Figure 16 shows the position of the head of the pit and of the mouthpiece of the flume in August, 1921. In October, 1924, the head of the pit at the surface was practically up to the lower dam and the mouthpiece had been advanced upstream about 200 feet. The distance between the head of the two pits was 2,700 feet. A cross-section at the head of the Lowhee pit was approximately 30,000 square feet and at the head of the Stouts pit 10,000 square feet. Taking the average cross-section of the ground between the two pits as 20,000 square feet, the total yardage is about 2,000,000 yards, or possibly 2,500,000 if the ground in the lower part of Watsons gulch is considered. In the absence of borings the only method by which the amount of ground available for hydraulicking can be estimated is by assuming as above that the channel varies uniformly in size between the two points where the size of the cross-sections is known. The average gradient of the bedrock in the part between the heads of the two pits is 4·5 per cent. As the gradient in the upper part of Stouts pit beyond the summit is very slight, it is probable that the gradient increases suddenly somewhere between the two pits. It is possible that the deep channel of Lowhee gradually narrows and continues to Watsons gulch and that there is an abrupt rise to the broad channel extending to the head of Stouts. If so, the sudden increase of grade will be of value when the hydraulic pit is extended upstream, in providing for a means of disposal of the tailings and preventing an excessive length of sluice flume, which is already very long and the up-keep expensive, and was especially so before the steel plates were put in. The average length of the channel hydraulicked out yearly in recent years, except when the grade of the flume was being changed, was about 150 feet representing about 200,000 cubic yards. In 1915, however, which was an exceptionally favourable year, nearly 225 feet were hydraulicked out in a section where the channel was somewhat narrower than above or below the section. With steel plates a much larger yardage can be handled than when the boxes were paved with wooden blocks, and it is probable that, on the average, 300 feet of the channel can now be mined each season. If so, the possible life of the mine is nine or ten years. The maximum production in any one year by hydraulicking was probably in 1915, during which year a "clean-up" of 2,300 ounces is said to have been obtained. The gold has been obtained from ground that was previously drifted on bedrock, and apparently the largest amounts were obtained at places where the old driftings were most extensive. Much of the bedrock was badly broken and the masses of angular slide rock and boulders were so numerous that thorough cleaning of the bedrock in the old workings was very difficult, which probably accounts for the fact that a considerable part of the gold remained to be recovered by hydraulicking. At the head of the hydraulic pit as exposed in October, 1924, the old driftings continue and are one to three sets wide. The old timbers exposed in hydraulicking include posts 11 feet high and 2 feet in diameter. The timbers are quite sound, although they have been underground for over forty years. There is a "balloon" drive with 3½-foot cap about 20 feet above bedrock, probably run for drainage. There is an old shaft, probably an air shaft, on the east side just above the lower dam, and the old workings may extend for a short distance above it. No shafts are known higher up and it is generally held by the miners that the ground above the air shaft, except possibly for a few hundred feet, has not been drifted. The value of the ground available for hydraulicking is not definitely known, but it is reasonable to suppose that it contains approximately the same values as the ground lower down and that in the part which was not drifted the values may be somewhat higher. It is fairly certain, however, that the ground was drifted as far as it paid for that kind of mining.

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 Watsons 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. The ditch is 240 feet above the bottom of the channel near the head of the pit and as the ditch is well above the summit a good head of water will be available for future work, although it will gradually decrease as the pit is extended upstream. The average head for the past few years has been about 250 feet. Only one No. 6 monitor is used during the dry season and two during the freshet. Taking the estimated amount of water available as 990 miner's inches, which includes the water used for a ground-sluice, for one hundred and seventy full days in the season and 200,000 cubic yards as the average amount of material mined, the average duty of the water per miner's inch a day was 1·2 cubic yards. Actually, a much larger supply of water was used on the average during the freshet and hydraulicking was done only intermittently during the dry season, but as the average number of days during which hydraulicking was carried on and the amounts of water used are not known, the average duty of the water per miner's inch, under actual working conditions, cannot be definitely determined. It probably does not differ greatly from the amount as estimated above. No very definite information is available regarding costs of producing the gold. The total amount of ground mined by hydraulicking during the past twenty years is probably at least 3,000,000 yards and the total production is said to have been between $400,000 and $500,000. The actual working costs of the mine probably do not exceed $10,000 a year, as only about eleven men, on the average, are employed during the hydraulic season. The overhead charges for equipment, ditches, etc., however, are fairly high.

The gold on Lowhee creek is mostly coarse and nuggety and is worth about $17.25 an ounce. The gold-saving devices in the flume that has recently been paved with steel plates, consist of riffles or spaces between the steel plates in the upper 150 feet of the flume, of three boxes paved with wooden blocks immediately below, and three boxes paved with wooden blocks at the lower end of the flume. There is also a trap or undercurrent for catching the fine gold, placed about 500 feet from the lower end of the flume. The trap consists of a grizzly in the bottom of the flume, which permits the fines to drop through into a large compartment beneath. Water from a 6-inch pipe under a head of 115 feet enters the box below the grizzly and causes an upward current which floats off the fine sand and mud and leaves the coarse sand and gold. A take-off pipe from the main pipe supplies water for sluicing the material which accumulates in the compartment or large box beneath the grizzly and which can be permitted to flow into small sluice boxes by opening a gate. The trap appears to be one of the most successful types of undercurrents that have been devised, the main difficulty being that it is not automatic, but requires a considerable part of the time of one man to operate it. Mr. Muller states that one-half ounce of fine gold was obtained in one clean-up and that he was not certain as yet whether the trap would pay for the time of one man to operate it. Probably much more fine gold is lost when steel plates are used than when the flume was paved with wooden blocks because of the much greater velocity of the water, but in most mines in the district, as at Lowhee, where nearly all the gold is fairly coarse, it has generally been held that the losses were negligible. It does not appear, however, that the question has been thoroughly investigated. In places in the district where fine gold occurs great difficulty has been experienced in saving the gold in hydraulic operations. It has been the general experience that unless the grizzly and undercurrent are placed at the end of the flume so that most of the fine material passes through the grizzly, the fine gold is likely to be lost, for it is carried in suspension in the muddy water. But placing the undercurrent at the end of the flume is in most cases not practicable because of the accumulation of tailings. The possible advantages of an undercurrent such as has been installed in the Lowhee flume are obvious, for a current of water is forced up through the water in the flume and tends to momentarily check the main current and cause settling of the fine material through the grizzly. The steel plates at the upper end of the flume were first placed with 3-inch spaces between them for riffles, and with $\frac{1}{2}$-inch rise on the upstream side. They were later changed so as to be level and to have 4-inch spaces between them. Mr. Muller stated that the latter arrangement had proved more satisfactory, and that further experimentation was being carried on to determine the best possible methods of saving the gold.

Jack of Clubs Creek

Jack of Clubs creek has its source near that of Williams creek in Bald Mountain plateau and flows northeast into Jack of Clubs lake. It is somewhat larger and longer than Williams creek and because Williams creek proved to be rich in gold it was held for many years that Jack of Clubs creek must be rich also. However, it has produced only about $225,000 in gold, although considerable mining has been done on it, whereas Williams creek, flowing north, has produced several millions. The creek, the lower part of which is shown on Figure 17, flows in a broad, deeply drift-filled valley in the part below the mouth of its main tributary Pinkerton creek. A short distance above the junction the creek flows for 800 feet in a narrow rock canyon. In this stretch and for 800 feet above the canyon the creek has formed a new post-Glacial channel. The old channel opposite the canyon in the lower part of Pinkerton creek is partly blocked by morainic deposits and is deeply drift-filled. Bedrock outcrops in the bed of the creek opposite the upper end of Tucker lake, and here, also, the deep buried channel is on the southwest side of the valley. A remarkably well-developed high channel drained by McLellan creek occurs on the northeast side and extends through to the valley of Jack of Clubs creek above the canyon. Its upper end is about 100 feet above the level of Jack of Clubs creek. In the upper part of the creek, a short distance above the part shown in Figure 17, there is a small rock canyon and a buried channel alongside. The ground in the valley bottom above the canyon is comparatively shallow—about 45 feet at the old Valincourt shaft just above the canyon—and no paying deposits of gold have been found in it. The deposits in the deep part of the creek below the canyon are 60 to over 200 feet thick and consist mainly of glacial gravels, with some glacial silt and clay and surface alluvium. Boulder clay occurs in places on the northeast side of the creek, but appears to be absent on the southwest side, where glacial gravels are abundant and largely conceal the bedrock. Deposition of glacial gravels on the southwest side of the valley, and lack of deposition of boulder clay, may have been due to the fact that during the closing stages of glaciation the ice remained longer on the northeast side of the valley and ice melting and stream action were pronounced on the southwest side. There are somewhat similar occurrences on other creeks in the area. The absence of boulder clay, except in a few places, and the porous character of the gravels, have caused difficulties in sinking shafts to mine the deep ground. These difficulties were largely overcome by sinking shafts in bedrock and drifting out to the channel. Once the channel was reached it was found that the ground could be sufficiently drained by pumping to permit of mining of the bedrock gravels. The following account of mining

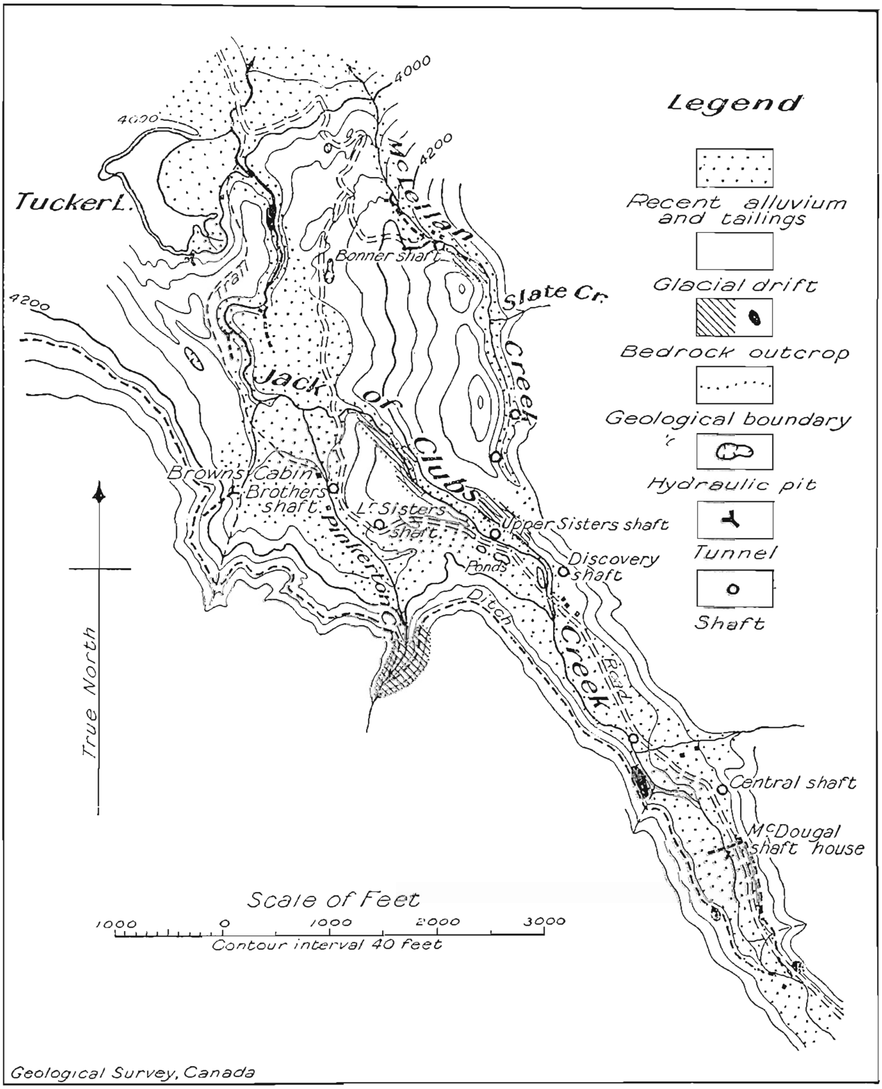

Figure 17. Jack of Clubs creek, Cariboo district.

operations on the creek is based mainly on information obtained from William Brown, who lived for many years on the creek, and from John McDougall, who worked in the old Central mine and has recently carried on mining operations at his property above the Central.

R. Byron Johnson, in his book "Very Far West Indeed," tells of the belief of the early miners in the possibilities of Jack of Clubs creek and of the first attempts to sink shafts in the bed of the creek. The deepest of these, however, reached a depth of only 60 feet. Adam Prentice is said to have sunk a shaft, in 1863, near the site of the Discovery shaft, to a depth of 130 feet, but not to bedrock. In 1869 the Discovery Company sank a shaft 150 feet to bedrock and drifted out into the channel, which proved to be 10 feet lower. In 1870 pay gravels were struck on the Discovery ground but they were interrupted by stretches of barren ground and by patches of hard, cemented gravels. About 300 feet of the channel upstream and a short distance downstream were mined, the total returns being about $26,000. Work was discontinued in August, 1873. In 1879 mining was begun on the Sisters group of claims, 1,600 feet long, below the Discovery. The upper Sisters shaft was 150 feet deep, 25 feet at the bottom being in bedrock and the drift from the bottom out to the channel being 25 feet in bedrock. The lower Sisters shaft was 190 feet deep, 100 feet in bedrock, and the drift out to the channel 160 feet. On the Brothers group of claims below the Sisters several shafts were put down, but were lost because of the wet, caving nature of the ground. Mining of part of the channel was eventually done from one shaft, shown on Figure 17. Brown's cabin on the left bank of Pinkerton creek is a short distance below it. The shaft was 170 or 180 feet deep. It passed through 50 feet of surface gravels and 50 feet of clay to bedrock. When the drive was made out to the channel it was found that the deepest part was at least 20 feet below the bottom of the shaft. However, an incline was constructed and the channel mined for about 300 feet downstream and for some distance upstream, probably to the ground worked from the lower Sisters shaft. The Sisters ground was later reworked by Joseph Shaw and the bedrock cleaned. In all, about 2,200 feet of the channel from the Discovery ground down to the Brothers was mined and produced, according to Brown's estimate, between $9,000 and $10,000 to the 100 feet of channel. As the companies were composed, for the most part, of local miners who did the work, the mining as a whole was probably done at a profit, although the ground was difficult to mine and the methods of mining expensive. In 1880 mining of the deep channel at a point 2,500 feet above the Discovery shaft was begun by the Central Company, and was carried on for about two years. The shaft was 97 feet deep, only a few feet at the bottom being in bedrock. A tunnel 340 feet long was driven to the channel and drifts 40 feet wide in places were carried upstream and downstream for about 150 feet. Some pay gravels were found near where the channel was entered, but when the drifts were extended upstream the pay gave out. Only about $5,000 is reported to have been obtained. McDougall holds, however, that all the gold was not accounted for. Small drives and raises along the bedrock at various places both upstream and downstream from the tunnel were made, but apparently nothing of value was found and the work was abandoned. In 1918 a shaft, located 500 feet above the Central shaft, was put down by John McDougall and F. Reed for the purpose of mining the deep channel above the Central ground. McDougall held that the gold values in the Central ground were higher than as reported and believed that the ground above would pay to mine. The shaft is 96 feet deep from the collar to the floor of the tunnel and there is a 9-foot sump. It passed through 14 feet of surface gravels and 58 feet of clay to bedrock. The total length of the main tunnel is 250 feet. At 196 feet from the shaft channel gravels appeared in the roof of the tunnel and extended for 40 feet. The tunnel was driven beyond the channel in the hopes that another channel would be found, but there is no doubt that the main channel was crossed. A drive upstream, starting at a point 225 feet from the shaft, was then made and mining of the channel gravels begun. Mining was carried on during part of 1922 by John McDougall and R. McDougall, and in 1923 by the two McDougalls and Harold Mason. The drifts were carried upstream about 125 feet. In places the channel was very narrow, especially in the upper part. In places in the lower part it was drifted three sets wide. One or two of the sets (8-foot cap) produced as high as 7 ounces, but the average was much less. Only about $1,700 in gold was recovered, and as the prospects for higher returns in extending the drifts did not appear favourable, work was discontinued in August, 1923. The mine was equipped with a water-wheel for power purposes, and water was rendered available throughout the year by a ditch 1,400 feet long from Jack of Clubs creek. At first the water bailed from the mine amounted to about 40 barrels a day. Later, the flow, which came mainly from the end of the main tunnel, amounted to nearly 225 barrels a day. The flow of water, however, was easily controlled by a continuous bucket-line hung in the pump chamber of the shaft and operated by the water-wheel.

The grade of the bedrock in the deep channel of Jack of Clubs creek along the part where mining has been done is somewhat irregular. In sinking shafts along the sides of the valley for the purpose of mining the deep channel the practice has been to determine the grade in the parts mined from the elevations and depths of the old shafts and assume a slight increase upstream or a slight decrease downstream. Irregularities in the grade, however, cause serious difficulties, although there was no difficulty in the case of the McDougall shaft, and the only sure way is to determine the depth of the ground by drilling. The grade of the channel, as determined from the elevations of the shafts and from the reported depths to the channels near the shafts, is as follows: between the McDougall and Central 5·0 per cent, between the Central and Discovery 3·1 per cent, between the Discovery and upper Sisters 3·5 per cent, between the upper Sisters and lower Sisters 5·5 per cent, and between the lower Sisters and Brothers 5·5 per cent. If the depth of the Brothers shaft is 180 feet the grade between it and the lower Sisters would be 7 per cent, which seems rather high. In any case a mistake was made in not sinking the Brothers shaft deep enough, for the channel proved to be at least 20 feet deeper than the bottom of the shaft. The unevenness of the grade renders it difficult or impossible to correctly estimate the depth to the channel in the lower part of the creek, even assuming that the reported depths of the shafts are correct.

Two tunnels in the lower part of the creek, the upper one 300 feet long and the lower one 400 feet, were run by William Brown in search of clay in which to sink a shaft to the channel. Assuming a 5 per cent grade for the bedrock from the Brothers shaft downstream, the depth to the channel from the level of the lower tunnel would be 225 feet. As already stated such an estimate may be quite misleading, but it is probable that the depth is at least 225 feet. A third tunnel, known as the Foch tunnel, was run into the bank opposite Brown's cabin in search of a buried channel, but did not reach bedrock. Tunnels were also run, in the early days, into the bank at the head of Tucker lake.

The gold obtained from the deep channel of Jack of Clubs creek is worth about $17 an ounce. It is fairly coarse and occurs for the most part on bedrock. The gravels as seen on the dumps of the old mines are in part similar to the "flat wash" typical of many of the mines in the area where rich gold-bearing gravels were mined, and contain numerous pebbles of barytes and other heavy rocks and minerals. Partly cemented gravels occur on bedrock in several of the properties and contain some gold. In the McDougall mine there is a very little cemented gravel on bedrock, most of the material on bedrock consisting of clayey, glacial gravels, with an occasional large boulder. It seems probable that the reason why the gold lead was not continuous and was markedly "patchy" in character is that the old gold-bearing gravels were eroded in places by ice action and replaced by glacial gravels, which contain only a part of the original gold deposited in the valley, and were enriched only slightly, if at all, by gold derived by glacial erosion of the bedrock. The main reason why Jack of Clubs creek was so poor in gold as compared with Williams creek must, of course, be that the gold-bearing veins from which the gold was derived are fewer in the basin of the creek than in the basin of Williams creek. The effects of glaciation in removing the old pay-streak were also more pronounced in Jack of Clubs creek, because the main flow of the valley glacier coming from mount Agnes was down this valley.

The high channel along the northeast side of the lower part of the creek has attracted considerable attention. Two shafts, one of which was 50 feet deep, but not to bedrock, are reported to have been sunk in it in 1877. Other shafts near the upper end were sunk later and a tunnel was run on Slate Creek tributary to the channel. Only a little gold was found, however, and no extensive mining was attempted except at the lower end, where mining development work was carried on from 1901 to 1904 by the Discovery Gold Mining Company of British Columbia, a New York Company of which Raymond E. Dodge was president and L. A. Bonner general manager. The property included the Discovery (real estate) claim of 30 acres and two 80-acre leases, the total frontage on the creek being about 3 miles. Bore-holes were put down to determine the depth of the ground near the lower end of the channel. A tunnel about 600 feet long was run and a shaft sunk at the end of it. Some gold was found in running the tunnel and in the lower part of the channel, but apparently not sufficient to pay and work was discontinued. Although the channel appears to be an old channel of Jack of Clubs creek, because it continues through to the valley of the creek above the canyon, it is too narrow to have carried the main drainage from the valley. It may have been formed by a small stream flowing in the same direction as the present stream, the headwaters of which were captured by Jack of Clubs creek. Alternatively, Slate creek may have flowed, at one time, southeast into Jack of Clubs creek and formed the upper part of the valley, and later its headwaters may have been captured by McLellan creek.

The tributaries of Jack of Clubs creek which have been mined to some extent include: Stony creek on the northeast side above the upper canyon; McDougall (Victoria) creek; and Queen of Clubs creek on the southwest side. Stony creek was mined in the early days and produced some gold. In 1905 an hydraulic plant was placed on it by A. Stott and Company, but only one season's work was done. The work is said to have about paid expenses. A shaft about 60 feet deep was put down on McDougall creek near its mouth and drifting done which is said to have paid $3 or $4 a day to the hand. Some gold was found on the creek nearly as high up as the Lowhee ditch. Some drifting was done by Herb Brown in 1921 along the side of Queen of Clubs creek a short distance above the mouth, but only a little gold was obtained. Very little gold was found on Pinkerton creek, which flows in its lower part in a deep rock canyon. There is probably a deeply drift-filled old channel on the northwest side which has not been mined. The Foch tunnel was run in search of it. The place where the old channel joins the deep channel of Jack of Clubs creek is not known. It may lie beneath the small creek near the Foch tunnel or be somewhat closer to Pinkerton creek. It probably contains some gold, but the fact that Pinkerton creek contained little gold discourages the view that the old channel would prove to be very rich.

The possibilities for mining on Jack of Clubs creek include the deep ground in the lower part below the Brothers shaft and the stretch of about 2,200 feet between the Discovery and Central old driftings. The Discovery claim and the ground above up to the Central claim is said to be held by G. D. Hage of New York, who was one of the directors of the Discovery Gold Mining Company of British Columbia. The ground varies from nearly 100 to about 150 feet in depth and whether the bedrock gravels are sufficiently rich to pay for mining by drifting—the only possible method—can be determined only by drilling. The ground in the lower part of the creek is probably at least 225 feet deep and there are serious difficulties in the way of sinking a shaft, except in bedrock, because of the general absence of clay. Here, also, if attempts are made to mine the deep channel, the ground would have to be drilled to determine the depth and values. There is some possibility for hydraulic mining in the lower part of the high channel drained by McLellan creek, but the upper part has a gradient of only about 2 per cent, which is too low for hydraulicking.

Little Valley Creek

Little Valley creek, a part of which is shown on Figure 18, flows southeast and forms the headwaters of Pleasant Valley creek. The latter creek in its upper part flows in a broad and flat-bottomed valley that is continuous with the Meadows or Williams Creek flats. Weldon lake, near the mouth of Little Valley creek, drains down Williams creek, but the summit between it and Pleasant Valley is only 2 or 3 feet higher than the lake. Little Valley is broad and deeply drift-filled throughout. Broad flats formed by the present stream occur in places and are interrupted, as below the West Canadian Deep Leads mine and lower down near the mouth, by morainic and glacial outwash deposits through which the stream has a comparatively narrow and deep channel. Only a few bedrock outcrops occur along the sides of the valley and at only one place in the valley bottom along the west side of the creek near its mouth. The position of the deep channel near the mouth is not known; it may extend either down Williams Creek valley or along Pleasant valley. The drift filling of the valley has a maximum depth

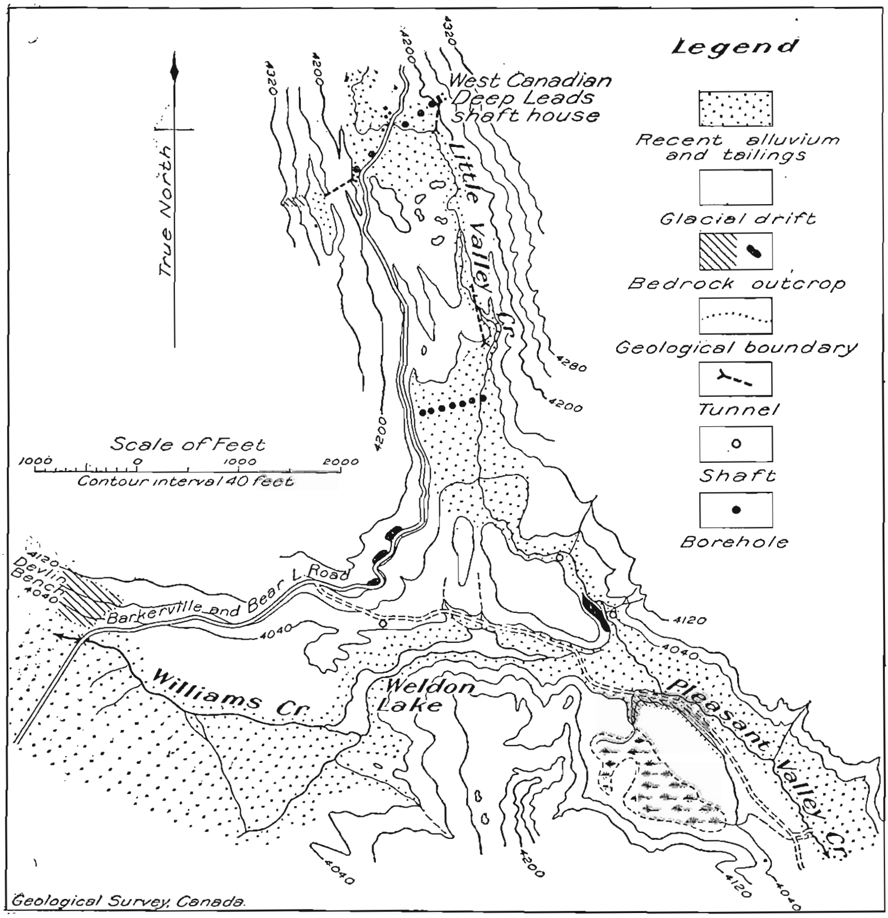

Figure 18. Little Valley creek, Cariboo district.

at the West Canadian Deep Leads mine of about 250 feet below the creek level. The upper part of the valley is also deeply drift-filled. Beyond the summit the main valley appears to be continuous and is drained by Summit creek flowing in the opposite direction. Mr. L. A. Bonner, manager for the West Canadian Deep Leads Company, to whom the writer is especially indebted for information regarding mining development work on the creek, put down three cross-sections of bore-holes, one at the mine, a second half a mile lower down on the creek, and the third on Pine creek, flowing nearly parallel to Summit creek and in a broad, drift-filled valley 2,000 feet west of Summit creek. The results of the borings showed that the bedrock in the deep channel is 30 to 40 feet lower at the mine than half a mile downstream, and on Pine creek is about 75 feet lower than at the mine. It is, therefore, reasonable to conclude—assuming that the deepest channel was reached in each case—that the drainage of Little Valley was formerly in a direction opposite to its present one and that the valley formed one of the main drainage courses of the region. If the conclusion is a correct one there must be 400 or 500 feet of drift overlying the bedrock in the valley at the head of the creek, which thickness appears to be rather excessive for the region, although thicknesses up to nearly 300 feet are known. It does not appear to the present writer, however, that the direction of the ancient drainage, whether it was the opposite of the present or not, has any great significance as regards the presence or absence of a rich pay-streak in the bedrock channel of the valley, because it is well established by the results of placer mining in the region that the gold is mostly local in origin and has not travelled far downstream, and unless the rocks in the immediate neighbourhood of a stream valley were originally gold-bearing to some extent there is little chance of a rich pay-streak occurring. It is, of course, true that fine gold and even some fairly coarse gold may be carried considerable distances downstream or that the gold may have been transported along with the glacial drift and have been reconcentrated to form payable placers in the stream bed. Several occurrences of this character are known in the district, but, as a rule, in such cases the pay-streaks are not on the true bedrock but on a false bedrock above.

Some gold is said to have been found in the early days on Jubilee creek, a tributary of Little Valley creek, and two or three shafts were sunk near the mouth of Little valley and some drifting done with no important results. It was not until 1895 that attention was especially directed to the creek by the discovery of placer gold along the right side of the valley, on what was afterwards known as the Discovery claim. The claim was worked by a company composed of local miners, including Joseph Wendle, A. Campbell, and others. The gold occurred in surface gravels resting on boulder clay in a depression in the glacial drift. A tunnel 390 feet long was run through boulder clay to the depression, water for hydraulicking was brought on the ground by a ditch 2 miles long from the upper part of the creek, and the gravels sluiced through the tunnel. Prospect pits 18 or 19 feet deep were put down in the pit to the rim rock of the valley. Red gravels were found beneath the clay, but nearly all the gold was in the surface gravels. The mining was continued for two or three seasons and although about 200 ounces of gold was recovered the operations are said not to have paid. The gold-bearing gravels occurred in a pot-hole or undrained basin in the glacial drift and the occurrence is the only one of its kind known in the district. The position of the pot-hole along the side of the valley above the valley flat and the fact that the pot-hole is not due to post-Glacial erosion suggest that the gold-bearing gravels in the depression were deposited by a stream flowing along or beneath the ice at a time when a glacier partly filled the valley. The source of the gold is unknown.

Mining development work directed towards mining of the deep channel of Little Valley creek was begun in 1902 by a syndicate of which L. A. Bonner was manager, and a shaft was started on the left side of the valley opposite the Discovery claim. A tunnel 300 feet long which tapped the shaft at a depth of 41 feet was run to carry off the surface water, but trouble was experienced in sinking and little progress was made for several years. In 1908 the two cross-sections of bore-holes shown on Figure 18 were put down, and in 1909 the West Canadian Deep Leads, Limited, was formed to exercise the option held by the original syndicate upon the leases, and took over the property. S. Herbert Cox of London, England, was consulting mining engineer for the company, and Mr. Bonner continued as manager. It was decided that the results of the borings warranted the outlay necessary to sink the shaft to bedrock. Apparently no reliance was placed on the borings as indicating the gold values in the ground, and it was later proved that the deepest part of the channel was not reached by the borings in the cross-section of the shaft. A three-compartment shaft was then sunk to a depth of 286 feet, the bottom 16 feet, including an 8-foot sump, being in bedrock, but difficulty was experienced in sinking because of the water pressure and the shaft was not completed until 1911. It was equipped with Cameron sinking pumps and two 18-inch Cornish pumps obtained from La Fontaine mine on Lightning creek. Two 80-horsepower and one 36-horsepower boilers were used for power. The Cornish pumps proved defective, as they were used at a much greater depth than at La Fontaine mine. A tunnel, however, was driven from the bottom of the working shaft towards the channel for about 250 feet and a blind shaft sunk 14 feet, proving that the deepest part of the channel was not reached by the borings. Some gold was found on bedrock at the bottom of the shaft, but apparently only a little in the channel gravels, although it was not certain that the deepest part of the channel was reached, and comparatively little actual mining was done. In sinking the shaft, cemented gravels were struck at about 110 feet. They were cemented in places down nearly to bedrock, but the channel gravels are said to be uncemented. In 1912 and 1913 a drain tunnel, which started 2,400 feet downstream from the shaft and was intended to tap the shaft at a depth of 100 feet and thus relieve the water pressure so that the pumps could easily control the water, was extended for about 600 feet, but the flow of underground water (seepage from the creek) is said to have caused trouble in running the tunnel. Operations at the mine were suspended in 1913. The partly cemented gravel on the mine dump contains a few well-glaciated stones. It is probable, therefore, that all the gravels down to bedrock are glacial gravels. It is possible, however, that there are some older gravels in the deep channel. The gravels are similar to those which are sometimes referred to by the miners as "cobblestone wash" and are rightly regarded as less favourable for placer gold occurrences in them than the "flat wash" seen on many of the dumps of the old mines, because the smooth, rounded gravels and boulders are typical of glacial outwash deposits, whereas the flattened, oval-shaped stones are typical of stream bed deposits formed, without a great deal of wear, from fragments of the country rock.

Mosquito Creek and Willow River Mine (Figure 19)

Mosquito creek is a short stream heading on the northeast slope of Island mountain and flowing into Willow river. Near its mouth it is joined by Red gulch, a larger and longer stream heading near the summit of the mountain. The two creeks are parallel and only a short distance apart for about 2,000 feet above Willow river, in which section they flow in drift-filled valleys. The bedrock valleys of the two creeks join at a point about 1,500 feet up from the road crossing of the creek, or at the lower end

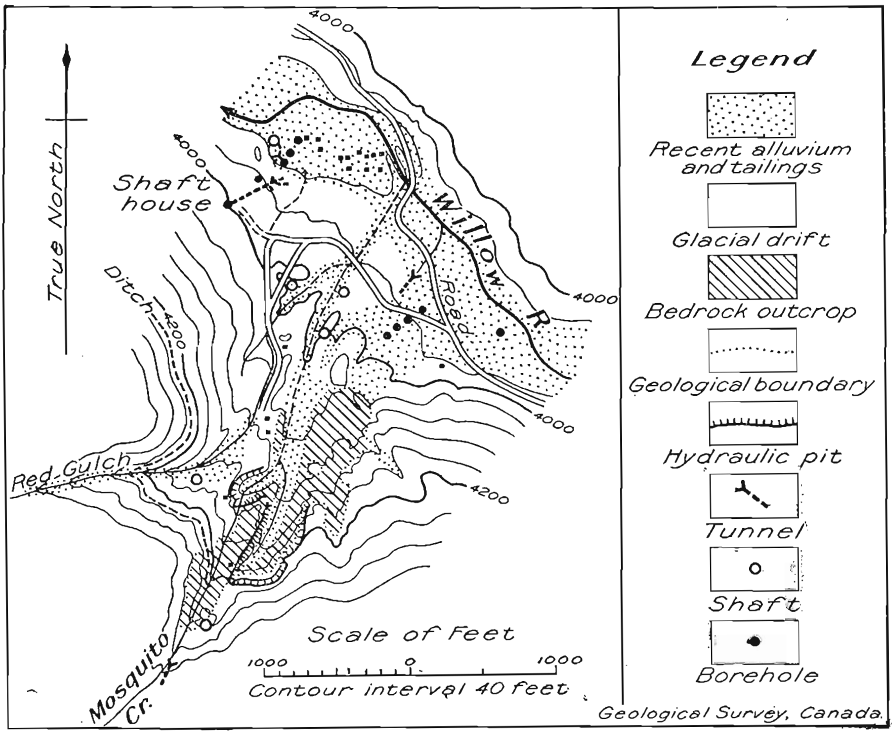

Figure 19. Mosquito creek, Cariboo district.

of the lower hydraulic pit. Lower down the deep channel bends to the west and enters the deep valley of Willow river somewhere in the vicinity of Willow River mine, but its exact location near the junction is not known. A shaft 300 feet above where the road turns up Mosquito creek is known as the Oliver shaft and is said to be located over the channel and to be 114 feet deep to bedrock. Its general course is parallel to, and, for the most part, on the east side of, the road leading up the creek. The channel is apparently graded to the deep channel of Willow river. A higher bedrock channel which was first drifted and later hydraulicked out, lies farther east and is approximately along the present course of the creek. A narrow drift-filled channel in which hydraulicking has been carried on in recent years, extends upstream at the head of the upper hydraulic pit. A remarkable feature of the creek is the series of irregular rock benches on the east side opposite the lower part of Red gulch and along the bed of the creek on the west side of the upper hydraulic pit. The benches have been cut through by the deep upper channel and proved to be very productive in gold. They slope gradually downstream and appear to connect with a buried channel which extends approximately along the course of the line of bore-holes near the junction of the main road and the Mosquito Creek road. The channel, however, has a higher gradient in its lower part than the benches and is, therefore, newer. The benches appear to represent old channels of the creek that were formed before the deep bedrock valleys were cut. They were somewhat modified by glacial erosion and before commencement of mining operations were almost completely concealed by glacial drift. It is extraordinary that they should have been preserved, even in part, and be rich in gold in spite of the effects of glaciation. The creek is said to have produced $3,500,000 in gold. This estimate is probably a somewhat exaggerated one, but there is no doubt that large amounts were obtained and that the creek for the length of the productive part—about one-half mile—has produced more gold than any other creek in the area.

Mining on Mosquito creek has been carried on to some extent practically every season since the sixties. The deep channels have all been mined by drifting, but there is some uncertainty as to how far downstream the deepest channel was drifted and whether driftings were carried below the old Oliver shaft. The lower parts of the channels near Willow river are said not to have paid so well as the upper parts, and probably the drifting was carried as far as the pay-gravels extended. Red gulch was mined partly by drifting and partly by open-cuts, but did not prove very rich except near the junction of its deep channel with that of Mosquito creek, although some gold was found on the creek, in places nearly to its source. Hydraulicking on Mosquito creek was carried on for many years by the Flinn brothers and since 1908 by John Hopp, who controls practically all the ground, but the operations have always been limited because of the small water supply. Water is obtained by a ditch along the northeast side of the mountain and there are two small reservoirs for storage purposes. Water sufficient for a No. 2 and a No. 4 Monitor is available for from two weeks to six weeks, depending on the season. Hydraulicking during the past few years has been carried on in the narrow, upper channel. The channel is V-shaped and is only about 50 feet wide between the rock rims at the top and averages about 40 feet in depth. The channel is filled with glacial gravels, with some silty clay beds 15 to 20 feet above the bottom, and boulder clay on the right bank near the top. The channel was drifted on bedrock and on a false bedrock of hard, silty clay about 20 feet above the bottom. In 1923, about 600 or 700 feet of the channel, up to where it joins the main creek channel, remained for hydraulicking. This represents only a few years work, as the channel narrows upstream and the pit has advanced during the past few years at the rate of about 100 feet a year, although only one or two men were employed in the work. There is also about 400 feet of channel extending from the head of the lower hydraulic pit to the lower part of Red Gulch channel, but this pit was abandoned and it is doubtful whether the bedrock in the channel can now be reached by hydraulicking except in the upper part, if sufficient grade for the sluice boxes is allowed, because of accumulation of tailings in the main pit. It is also doubtful what gold values remain in the ground, for it was drifted in the early days. Much of the ground hydraulicked on the creek is said to have averaged nearly 50 cents a yard. There is known to be a small amount of pay-gravels beneath the drift hill at the lower end of the rock benches on the east side of the creek and there is some possibility of finding extensions of the bench pay-gravels, although several draws leading to the benches were hydraulicked out and the pay on the benches was found to end abruptly. Several bore-holes in the channel below the benches on the east side of the creek were put down in 1914 by J. T. Towers, representing Boston capital. The drilling proved a small area of dredging ground, the maximum depth of which is about 100 feet. The average value is said to be nearly $1 a yard.

Willow River mine is located on the south side of Willow river a short distance below the mouth of Mosquito creek. Although mining operations ceased in 1908 they are of interest because they furnish some evidence regarding gold values in the deep channel of Willow river, and because of the difficulties encountered and finally overcome and of mistakes made in carrying on the work. The following account of the mining operations is based on information obtained from Laurent Muller, who was mine manager for a time, at the mine, from the mine plans, and from the manager's reports in the Annual Reports of the Minister of Mines, British Columbia.

The mining and development work was done by the Willow River Mining Company, of which F. C. Laird was manager and chief shareholder. Work began in July, 1894, and continued during parts of each year until the spring of 1908. The operations were somewhat similar to those at Slough Creek mine and the difficulties encountered were at first nearly as great, although the ground at Willow river is not nearly so deep as at Slough creek. Mining of the deep channel, to some extent, was finally accomplished by sinking a shaft to bedrock in the valley of Willow river and drifting from the bottom of it, in spite of the fact that the deposits overlying the bedrock consist entirely of gravels, whereas attempts to mine the deep channel by drifting from a shaft sunk in bedrock on the southern side of the valley proved failures. Seven bore-holes, the locations of four of which are shown on Figure 19, were first put down to determine the depth and location of the deep channel. The data obtained from the borings, however, were later proved to be inaccurate and this inaccuracy caused a great deal of trouble and expense, for the channel proved to be several feet deeper than the bore-holes had shown it to be. A tunnel was started at water-level, 300 feet west of the line of bore-holes, and was run south 620 feet to bedrock. A shaft was then raised 92 feet to the surface and sunk in bedrock, the total depth from the collar of the shaft to the floor of the main tunnel being 192 feet. The main tunnel was extended 485 feet, to where gravels appeared in the roof, and was timbered throughout, because of the soft character of the rock. The tunnel had a high grade and at its end was 4 feet higher than at the shaft. Several drives in different directions from near the end of the main tunnel were made and it was found that when the gravels were reached by breaking out from the bedrock very great pressure developed and heavy runs of water, mud, and gravel occurred, which drowned out the pumps, although the shaft was equipped at different times with several sets of pumps of various designs, having a maximum capacity of 3,000 gallons a minute. In some of the drives heavy oak timber and steel rails were used for timbering, and an air lock, designed to withstand a considerable pressure, was placed in the main tunnel, but proved of little value, because as long as the ground was undrained the heavy pressure continued and apparently the ground could not be drained by pumping under the conditions which obtained. Attempts to mine the ground by drifts from the hill-shaft tunnel continued until 1902 when a "gravel" shaft was started on Willow River flat 160 feet below the line of bore-holes. The shaft was equipped with two 18-inch Cornish pumps actuated by a water-wheel and with one steam pump. A drain tunnel, which tapped the shaft at a depth of 15·5 feet, was run for 1,100 feet. The shaft was then sunk to bedrock and continued a few feet into the rock. A tunnel, the floor of which was 91 feet 3 inches below the collar of the shaft, was driven to intercept the channel and mining of the channel gravels begun. No serious difficulty was met with in draining the ground, although no mining could be done during the freshet and about two months pumping, starting about July 1, were required to drain the ground each year. Mining could then be carried on during the autumn and winter. Once the ground was drained there was very little pressure in the face or overhead in the drifts to contend with. During these operations about forty sets were taken out, but it was soon found that the deepest part of the channel was at least 11 feet below the level of the floor of the tunnel and, therefore, could not be mined. The main tunnel from the hill shaft was about 4 feet lower at its end than the tunnel from the gravel shaft. It was then decided to deepen the main or gravel shaft and, as the depth of the deepest part of the channel was not definitely known, it was decided to deepen it 25 feet in order to be certain that the lowest part of the channel could be reached. The method of deepening the shaft was designed by Laurent Muller, who was appointed mine manager after the death of F. C. Laird, in 1906, and the shaft deepening was accomplished under his directions in 1906 and 1907. The chief difficulty to be contended with in deepening the shaft was that the two 18-inch Cornish pumps, the pump columns of which rested on bedrock in the two pumping compartments, were working nearly to capacity in order to keep the mine free of water. To overcome this difficulty clay puddle was placed outside the shaft timbers in the lower part of the shaft and around the pump chambers. This cut off most of the water coming from the bedrock. The water coming from above was caught in a trough around the outside of the shaft and carried to the pump chambers. The main compartment was thus rendered nearly dry and sinking could proceed in it. Sinking was then carried to the full depth, another trough with clay puddle around it being placed lower down and the water from the trough pumped to the upper chamber by a third small pump. Raises the full size of the shaft were then made from the bottom and as the flow of water had decreased because of the clay puddling and because of a tunnel driven from the bottom carrying off some of the water, it was found possible to divert nearly all the water to one pump, and to lower the other and place it in position in the bottom of the shaft. The raises were then continued in the other pumping compartment and the second pump lowered to the bottom. The total labour cost of the operations was $3,138.62 and the time consumed forty-nine days.[1] In 1907 a tunnel 7 feet lower than the old tunnel was run from the shaft and mining of the channel again started. Work was continued during the autumn of 1907 and following winter. The ground mined during the final operations is said to have paid as high as 7 ounces to the set, but although the mine was then fairly well equipped and a new boiler had been brought on the property, work was discontinued, probably because it was realized that the ground was not rich enough to yield adequate returns for the very heavy expenditure—probably at least $300,000—incurred in development work. If the maximum depth of the ground had been accurately determined by drilling, the gravel shaft sunk in the first place to the proper depth, and waterpower used for pumping, it is possible that mining of the ground would have paid.

An interesting question in connexion with the mining operations is whether they were done in the deep channel of Mosquito creek or in that of Willow river. The operators held that the workings were in the channel of Willow river, for the most northerly bore-hole in the valley flat of the river showed a depth of only 50 feet to bedrock, whereas the deepest part found in the driftings was 102 feet below the level of the collar of the gravel shaft, which is 1 or 2 feet below the level of the bore-hole. Assuming that the reported depth of the Oliver shaft is correct, the bedrock grade from the Oliver shaft to the Willow River gravel shaft is about 5 per cent, which is about what is to be expected if both shafts are in the same channel. There is room for another deep channel on the north side of the Willow River flats and it is possible, although it does not seem very probable, that a somewhat deeper channel than the one mined exists. There is no reason to suppose, however, that it would prove to be any richer than the channel mined, for the latter is closer to the rich productive part of Mosquito creek. Before mining operations began it was believed that the channel would prove to be rich, merely because Mosquito creek was rich, for no reliance was placed on the borings for determining the gold values in the ground. The drilling was done with an hydraulic jetting machine and at that time the science of testing ground for depth and gold values was not developed to any great extent. This proved very unfortunate, for not only was a costly mistake made in determining the depth of the ground, but the values in the ground proved to be much smaller than were expected. A significant feature of the mining development work is that it was fairly definitely proved that in places where the ground is porous and 100 feet or more in depth it is very difficult to drain the ground by pumping from a bedrock shaft and tunnel breaking into the channel, and that very great pressure develops in the workings because of the water pressure in the ground. Strangely enough, it was found possible to drain the ground and relieve the pressure almost entirely by sinking and pumping from a gravel shaft, in spite of the porous character of the ground and the presence of a good-sized stream flowing in the valley flat. The gravels are cemented in places below a depth of 50 feet and their partly cemented character, in causing a

[1] Boursin, H.: "Puddling a Wet Shaft"; Min. and Sci. Press, Jan. 25, 1908, p. 129.

comparatively slow circulation of water through them, may account for the fact that it was possible to drain the ground. Also, the ground was drained gradually during the process of sinking the shaft, whereas in the case of the bedrock shaft and drives to the channel the full pressure developed at once when the channel was entered and flows of water and mud occurred which drowned out the pumps. Mining from the gravel shaft, however, had the serious disadvantage that operations had to be suspended during the freshet and about two months pumping was necessary each year after the freshet, before mining could begin.

The Meadows

The Meadows or alluvial flats of Williams creek and Willow river extend northwest for 5 miles from Weldon lake at the junction of Pleasant valley and Williams Creek valley to Jack of Clubs lake, and are continuous with the narrower flats of Willow river, which extend for many miles downstream. They vary in width from 500 to 3,000 feet and the surface for the great part is remarkably even—for it is the result of alternate erosion and deposition by the present streams—but here and there small "islands" of glacial drift rise a few feet above the general surface. They show that the valley filling is mainly glacial drift and that the Recent stream deposits have no great thickness except locally. There are extensive and thick deposits of tailings on the flats opposite the mouth of Lowhee creek and, to a less extent, opposite the mouth of Williams creek proper. The surface grade of the flats along a direct line following the general course of the creek from the mouth of Mosquito creek to the upper end of the flats averages only 0·6 per cent. Jack of Clubs lake is at the level of the flats and drains into Willow river. Near the upper end of the lake there is a low divide 26 feet high, which is all that prevents the water from draining down Slough Creek valley, a much wider and more deeply drift-filled valley than that of Willow river at Island mountain. Jack of Clubs lake, as determined by soundings, has a maximum depth of about 175 feet and a soft mud bottom. The deposits in Slough Creek valley beyond the head of the lake are partly morainic deposits of a valley glacier. It may be that a mass of ice occupied the lake basin during the closing stage of glaciation and, being protected by its position at the foot of the steep northwestern slope of Cow mountain, remained for a long time and prevented deposition to any great extent in the basin; or it may be that deposition by the glacier moving down Jack of Clubs valley partly blocked Slough Creek valley and dammed the lake at the upper end, while deposition by streams blocked the lower end. There is no evidence that the lake occupies a rock basin—although it may be partly so—for the valley of Slough creek is known to be deep at the mouth of Jack of Clubs creek and lower down at Slough Creek mine and is, therefore, probably a deeply drift-filled valley throughout. The bottom of the lake is considerably lower than the deep channel of Willow river at Mosquito creek. This greater depth may be due to ice erosion, or possibly the main drainage of Williams creek was at one time by way of Slough Creek valley—a view which is borne out by the greater width and depth of Slough Creek valley as compared with Willow River valley. It is possible also that the drainage of parts of the valleys was at one time in the opposite direction down Pleasant valley to Antler creek. These changes in drainage however, have comparatively little significance regarding the occurrence of placer gold deposits, for the valleys, in spite of the changes in direction of drainage, have, for the most part, merely been widened and deepened and the gold is mostly local in origin and has not travelled far downstream. Of far greater importance are the effects of glacial erosion in the valleys. The bedrock valley of Lowhee creek at its mouth is hanging with respect to the main valley, as are also some of the tributary valleys above and below Jack of Clubs lake. This fact suggests overdeepening of the main valley by ice erosion. On the other hand, Mosquito creek appears to be graded to the deep valley of Willow river, and Williams creek, where it enters the Meadows, is graded to the deep channel beneath the upper part of the Meadows. The evidence as to glacial erosion is thus conflicting. It may be that ice erosion widened and deepened the main valleys in places or even throughout the greater part, and that later, during a temporary absence of the ice, some of the tributary streams deepened their channels and became graded to the bottom of the main valley, whereas other streams did not. Williams creek has two deep valleys in its lower part near the Meadows, one through the Forest Rose ground being about 50 feet higher than the bottom of the main valley, which is graded to the deep channel of the meadows. On the other hand Eureka and McArthur gulches, short streams flowing into the meadows from the northeast face of Barkerville mountain, are not graded to the deep channel of the Meadows. The channels of these streams possibly illustrate the processes of erosion as stated above. The deep channel of Williams creek, however, appears to be very old, for it contains two series of glacial deposits with an interglacial pay-streak between them, as well as the rich pay-streak on bedrock now mined out. It is difficult to conceive how after a first advance and retreat of the ice, the glacial drift could have been eroded and the tributary streams have cut deep valleys into the bedrock at such low levels. It may be that glacial erosion widened and deepened the main valleys only in places, as near Jack of Clubs lake, but—and this is the important point regarding the occurrence of placer gold—it is fairly certain that glacial erosion in the wide and deep main valleys was sufficiently great to have removed any preglacial pay-streaks. The pay-streaks that remain must, therefore, be glacial or interglacial in age. The surface or postglacial pay-streak is only slightly developed and is not of importance, for although the flat surface has been formed by alternate erosion and deposition by the present stream, there has not been sufficient erosion to effect much concentration of the gold scattered through the drift or transported from the upper part of the stream.

The question whether a rich pay-streak occurs in the deep channel of the Meadows has never been definitely settled, in spite of considerable prospecting and mining development work. In 1870 the Lane and Kurtz Mining Company secured a lease of 5 miles of the Meadows and attempted to mine the deep channel by drifting from a shaft. The shaft is located on the south bank at the narrowest part of the Meadows, near where the Downey Pass road leaves the main highway. The collar of the shaft was about 15 feet above the level of the creek. According to Mr. C. C. Lane, superintendent of the Lane and Kurtz Mining Company, as stated in a letter addressed to John Hopp, the depth of the shaft to the level of the tunnel driven beneath the Meadows was 120 feet. The depth to bedrock in the shaft was 90 feet. The shaft was equipped with two 9-inch Cornish pumps and a large Cameron steam pump placed in a chamber near the bottom of the shaft. The use of the pumps for two seasons proved sufficient to drain the ground, both near the surface and lower down. About 10 cords of wood a day was used as fuel for the boilers. A water-wheel intended to operate larger pumps was placed on the ground, but these pumps were not used. The drift under the Meadows, according to Mr. Lane, was 75 feet long. In the account of the operations given in the Annual Report of the Minister of Mines, British Columbia, 1874, the length of the drift is given as 180 feet. The drift, except for a few feet out from the shaft, was run in gravels and the deep bedrock channel was not reached. Mr. Lane states that about 2½ ounces of fairly coarse gold was obtained by cleaning up the rim rock and there was a slight showing of gold in the gravel taken out in running the drift. When it was realized that the channel was much deeper than had been supposed and that the development work was very costly—at least $60,000 having been expended with practically no returns—operations were suspended in 1873. Since that time no serious attempt has been made to mine the deep channel in the Meadows except lower down at Willow River mine and at Slough Creek mine, both of which undertakings, however, proved failures. It was at one time proposed to drain and mine the upper part of the Meadows by running a tunnel from the falls in the lower part of Pleasant valley, but the project was abandoned as too costly. An old shaft in the flat opposite Devlin bench is said to have been 136 feet deep, but not to bedrock. In 1913 a number of borings in the flats were made by E. H. Dawson with the object of determining whether the ground was sufficiently rich to pay for dredging. Other borings were made by J. T. Towers in 1914 along Williams creek near the upper end of the Meadows, at the mouth of Mosquito creek, near the junction of Cornish creek and Willow river, and a short distance below the rock canyon on Willow river below the junction of Slough creek. Two borings were made on the south side of Williams creek, 850 feet below the Lane and Kurtz shaft. There were two borings, one on the bank of Williams creek and the other 700 feet farther south and 1,000 feet north-west of the reduction works near the mouth of Eureka creek 1½ miles from Barkerville. Three bore-holes, two of which were near the south bank and the other near the centre of the valley, were put down along a line 1,750 feet above the reduction works. Another was located 1,000 feet farther up the valley and 500 feet from the south bank. There were also a few others the location of which is not known. Unfortunately, these borings extended down only to clay or to what was considered as dredging depth, and, therefore, furnish no information as to the gold values in the deep channel of the Meadows. Some very fair values are reported to have been found in the borings along the sides of the valley, below Devlin bench opposite the part of Williams creek above the Meadows, and off the mouths of the tributary streams on the south side of the Meadows, but very little in the borings in the central part of the valley. Eureka and McArthur creeks were gold-bearing to some extent and were first drifted and later hydraulicked out in their lower parts. The borings and old workings in the lower part of Williams creek above the Meadows showed that there is an interglacial pay-streak about 60 feet from the surface. The drain tunnel for the Gold Fields elevator, on Williams creek at the entrance to the Meadows[1], is said to have followed this pay-streak for some distance. The pay dirt excavated in running the tunnel was brought to the surface in a shaft 60 feet deep located about 1,000 feet below the elevator and is said to have averaged nearly a dollar a yard. This pay-streak may continue beneath the surface for some distance down the Meadows. The only facts bearing on the question whether there is a rich pay-streak in the deep channel of the Meadows are that the pay in the deep channel of Williams creek where it enters the Meadows is known, from the record of mining the channel in the early days, to have been not nearly so rich as in the narrower parts higher up—partly because the pay was distributed over a much wider area—and that the deep channels mined at Willow River and at Slough Creek mines did not prove very rich. If the channel has a very low gradient it is reasonable to suppose that the pay-streak would be wide, as was found to be the case on Lightning creek at the La Fontaine mine where it was so wide, and, therefore, relatively lean, that it did not pay to mine. The average bedrock gradient of the deep channel from the mouth of Mosquito creek to the head of the Meadows is practically the same as the surface gradient or about 0·6 per cent, if the elevations of the bedrock in the channel at the two places are alone considered. It is probable, however, that the deep channel turns down Slough Creek valley at Jack of Clubs lake and that the ground at the Lane and Kurtz shaft is 150 feet or more in depth which, if so, would give a gradient, for the part above, of at least 1·2 per cent, but such a gradient is not very high. There are also theoretical considerations which, as already pointed out, discourage the view that any very rich pay-streak occurs in the deep channel of the Meadows, because of the effects of glaciation, but the question is an open one and can probably be decided only by borings.

Eightmile Lake

Eightmile lake (Figure 20) 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

[1] Geol. Surv., Canada, Sum. Rept., 1921, pt. A, Map 1942.

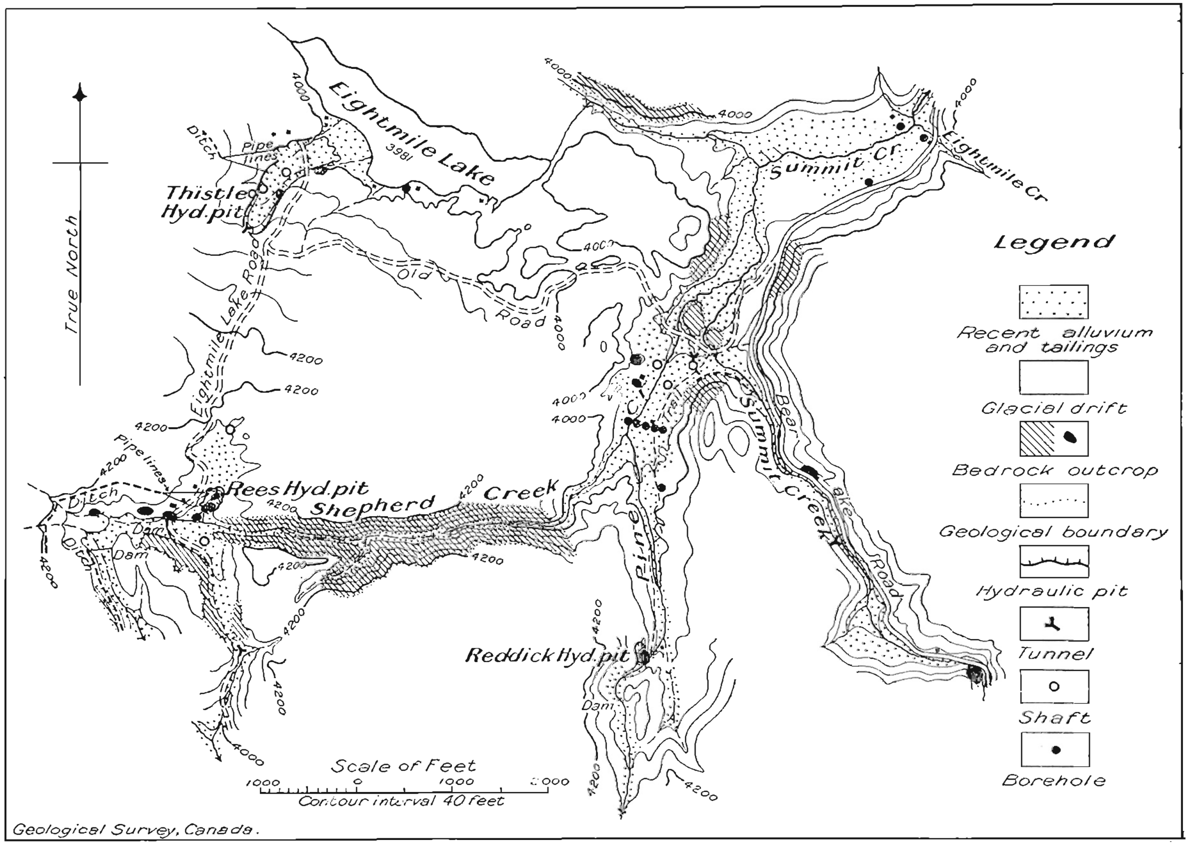

Figure 20. Eightmile lake, Pine and Shepherd creeks, Cariboo district.

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.

Placer gold was discovered at Eightmile lake in 1897 by Pat McKenna and Billie Ogden, who ground-sluiced and hydraulicked on a small scale for two seasons. The property was then optioned to the Sutherland Hydraulic Mining Company, Limited, of which B. A. Lasell was manager. Water for hydraulicking on a large scale was brought by a ditch, 4 miles long, from Stewart creek, flowing into Valley creek from the south. In 1901 the property was acquired by the Thistle Gold Company, Limited, of which R. Hannah, of Minneapolis, was president and principal owner. James Ross, now one of the owners and operators of the mine, was manager. The company also purchased the Coffee Creek mining interests. From that creek and from other small streams along the side of Big valley they increased their water supply. Coffee creek lies between Stewart creek and Eightmile lake. Both creeks are outside the area included in Map 2046. An hydraulic plant was installed on Coffee creek in 1901 and hydraulicking was carried on for a few weeks during the freshet for three seasons. At other times all the water available—an average head of about 100 feet— was used at the Thistle pit. Water was available for two No. 2 monitors with 3-inch nozzles, for sixty to one hundred and fifteen full days in the year, the average being about ninety days. In nine seasons about 360,000 yards of ground were mined. The gold production is said to have amounted to nearly $375,000. About ten men were employed, on the average, during the hydraulic season only. The flow of water used in hydraulicking was approximately 240 miner's inches and the average duty of a miner's inch was about 1·8 cubic yards per 24 hours.

Hydraulicking started near the lake shore, and as the cut was extended upstream it was found that the grade of the channel was very low. The sluice flume was laid on a grade of only 4 inches to the box, and it was difficult to dispose of the tailings. In 1904 a cut, about 500 feet long, made at the outlet of the lake, lowered it about 4 feet. Mr. Ross, to whom the writer is indebted for information regarding the property, states that, after this lowering, bedrock could be seen in the bottom over a considerable part of the lake near the lower end. The lake was originally about 40 feet deep in the deepest part, but has been largely filled by tailings. In 1909 an hydraulic elevator was used at the head of the pit where the bank is steep and about 50 feet high, for the inclination of the pay-streak was so low that it could no longer be reached by hydraulicking, but the elevator proved a failure. There was about 40 feet of boulder clay at the top in the bank at the head of the pit and it was found necessary to break it up by bank blasts, in two of which several thousand pounds of powder were used. It was then proposed to mine the ground beyond the head of the pit by drifting. A tunnel (Figure 20) was run for about 100 feet into the bank at the head of the pit. A drive was run from the end and struck steeply dipping rim-rock on the east side at 10 feet. A pit at the end of the tunnel was also sunk 6 feet to a bed of boulders similar to those beneath which the pay-streak occurred in the pit. Two ounces of gold to the set was obtained on the rim-rock, but sinking could not be continued because of the ground-water. In recent years mining at the property has been carried on by Messrs. Ross and McComish, the present owners. Hydraulicking has been carried on in the lower west side of the pit, two small monitors being used, one for sluicing and the other, placed at the lower end of short lengths of sluice boxes, for boosting the tailings.

The materials overlying the bedrock at the hydraulic pit consist of boulder clay at the bottom overlain by poorly stratified glacial gravels and silt which are again overlain in places by boulder clay. The upper surface of the lower boulder clay, as exposed in the pit, is partly cemented to a depth of a few inches and resting on the surface was a bed of large boulders, now scattered and partly removed by mining operations, beneath and around which the pay was found. The pay-streak was nearly 50 feet wide in places and divided upstream into two branches. One branch extended practically to the surface about 500 feet westerly from the head of the pit; the other branch lies beneath the high bank at the head of the pit. The materials overlying the pay-gravels in the lower part of the pit were mostly glacial gravels, averaging only 10 to 20 feet in thickness; the material at the head of the pit is mostly boulder clay and has a maximum thickness of nearly 50 feet. The true bedrock outcrops in a few places along the east side of the pit, but not on the west side. An old shaft near the centre of the pit, the upper 15 feet of which has been hydraulicked away, is said to have been 29 or 39 feet to bedrock and only a little gold was found on bedrock. There are two shafts on the west side of the pit; the upper is said to have been 22 feet to bedrock and the lower, sunk by Pat McKenna, Joseph Wendle, and others, is said to have been nearly 80 feet deep and not to bedrock, but there was broken bedrock on the west side most of the way down. No gold was found except in a thin pay-streak about 60 feet from the surface. It is evident, therefore, that, although there appears to be a deep bedrock channel beneath the hydraulic pit, the placer gold does not occur in the bedrock channel, but in gravels resting on a false bedrock of boulder clay deposited by a glacier, and the pay-gravels may have no connexion with the buried rock channel. After the deposition of the lower boulder clay there was a period of erosion during which the pay-gravels may have been deposited by a stream flowing northeast towards the basin of Eightmile lake. But, since the numerous large boulders forming part of the pay-gravels could hardly have been transported by the stream, it is more probable the pay-gravels were formed by stream erosion of the underlying boulder clay and that the concentration of the gold was due to this erosion. The gold was derived from the glacial drift. Before it was included in the glacial drift it probably occurred in a pay-streak in one of the deep bedrock channels, and not necessarily in the channel above which it now occurs. The bedrock where exposed in the hydraulic pit is crystalline limestone. The boulders in the lower boulder clay and those partly forming the pay-streak consist of rocks that were derived in part from the mountain range to the east and southeast. Many were derived locally. There are numerous boulders of a reddish weathering, igneous rock, numerous dykes of which occur on Shepherd creek three-quarters of a mile to the south. One occurs in the hydraulic pit on Shepherd creek and others are exposed in the canyon of that creek and in the upper part of Pine creek. They trend northwest and some of them may extend nearly to the Thistle pit. There is a very striking rock channel, filled with glacial drift, crossing Shepherd creek and trending parallel to the road in the general direction of the Thistle pit. It seems possible that the gold in the Thistle ground was originally derived from this channel or from Summit and Pine Creek valleys (*See* description of Pine creek) by glacial action and was later reconcentrated by stream erosion of the glacial drift. There are no glacial striæ on the rocks in the vicinity which might furnish a clue as to the direction in which the ice moved, but it is reasonable to suppose that the ice coming from the mountain slope to the east would tend to flow north down the main valley at the foot of the mountain slope. In any case some of the boulders in the deposits at the Thistle pit must have been derived from the rocks of the mountain ridge to the east and southeast, for they are similar to them and are unlike either the underlying rock or the rocks to the west. It is reasonable, also, to suppose that the stream which formed the pay-streak flowed down Big valley, for it is probable that, during the melting of the ice previous to the last advance the deep valley to the east was blocked by the ice and by glacial drift. Another fact which shows that the pay-streaks in the old bedrock valleys of the neighbourhood were eroded by the ice is that the materials hydraulicked in recent years on the west side of the Thistle pit are glacial gravels included in the upper drift sheet. There is no definite pay-streak, but large masses of the gravels included in the drift sheet contain gold scattered through them.

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. Mr. Ross holds that it trends southwest and not in the direction of the Shepherd Creek cross-channel. As already pointed out the pay is above the bedrock in the channel and, therefore, the stream that formed it may not have been controlled in direction by the cross-channel, although the gold may have originally been derived from it. 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.

Shepherd Creek

Shepherd creek (Figure 20) flows northeast into Pine creek and in the dry season has a flow at the junction of only 6 or 7 miner's inches. In the part east of the Eightmile Lake road it flows in a narrow, deep, V-shaped rock valley. Near the road the valley is wide and there is a cross-channel, partly drift-filled, extending at right angles to the stream. The cross-channel extends south for 1,200 feet to where the ground slopes rapidly to the valley of Downey Pass creek. It extends north for at least 1,200 feet and possibly to the Thistle pit at Eightmile lake. The grade of the channel is towards Shepherd creek, although a cut at the lower end, 40 feet deep from the surface, would drain the deepest part of the channel of Shepherd creek at the intersection. The flat on Shepherd creek above the road is nearly at the same level as the wide part below the road and can also be drained down one of the branches at the head of Downey Pass creek by a shallow cut. The creek in the upper part above the flat has a steep gradient. There is thus a series of old stream channels that have been partly cut away by more recent streams and have been modified by glacial erosion and deposition. The channels are partly drained at the present time by Shepherd creek flowing to the east in a rock valley, the banks of which are much higher than the ground to the west along the cross-channel. The rock canyon of Shepherd creek was, judging by its narrow, steep-sided character, formed more recently than the upper, broad channels. Its cutting by headward erosion, by a branch of Pine creek, probably caused capture of the upper part of the creek and of the cross-channel, which may have formerly drained partly towards Eightmile lake and partly down Downey Pass valley. The canyon is not postglacial in age, for there is some glacial drift in places in the bottom of it, but it has probably been deepened somewhat in postglacial time. It may be glacial (Pleistocene) or interglacial in age, but its youthful character practically precludes its being preglacial.

Placer gold was discovered on Shepherd creek, near the junction of the cross-channel, in 1892, by E. C. Shepherd. Several shafts were sunk about 22 feet to bedrock in the channel and much of the shallow ground on the rock benches along the southwest side of the ground was mined. In 1900 the Discovery Company of which E. Odlum, Vancouver, B.C., was managing director, tested the ground and constructed a new ditch for hydraulicking. Since 1914 the property has been owned by R. D. Rees, who has been able to hydraulick on only a small scale because of the deficient water supply and of difficulty in disposing of the tailings. A No. 2 monitor is used and a good supply of water is available for a few weeks during the early part of the season and occasionally for a short time in the autumn, but practically none during the dry season. During the past few years a pit has been opened in the channel extending north from the creek and east of the road. The deposits overlying the bedrock are only 5 to 15 or 20 feet thick and consist of swamp muck at the surface underlain by glacial gravels cemented in a few places, and boulder clay. There is a narrow, deeper channel on the west side of the pit which cannot be reached by hydraulicking. An old shaft 600 feet up the channel from the head of the pit is 53 feet deep and unless it is sunk partly in bedrock, which does not seem probable, it shows that the bedrock in the channel may slope towards Eightmile lake, for the bottom of the shaft—and it may at one time have been deeper—is practically at the same level as the bedrock in the hydraulic pit. In any case the grade of the channel is so low that the hydraulic pit cannot be extended much farther without losing the bedrock, except along the sides of the channel. There is some gold, however, in the gravels along the east side of the channel. Mr. Rees states that the gold is very unevenly distributed and is most abundant on bedrock and where the bedrock is hard and uneven. In order to overcome the difficulty of disposing of the tailings it was proposed at one time to drive a tunnel for about 2,600 feet up the creek to the junction of the cross-channel, but the scheme was abandoned as being too costly and not justified considering the small supply of water available for hydraulicking, although the ground that was tested showed values of over a dollar a yard in places. The extent of the ground, however, and the average value are not known. The creek has a fall of 165 feet in a distance of 4,500 feet in the narrow part, downstream from the cross-channel. The amount of water available for hydraulicking, as estimated from the drainage area and from the precipitation, is, on the average, about 100 inches for forty full days in the year. Using a No. 2 monitor under a head of 100 feet the maximum amount of ground which could be moved yearly would be about 7,200 yards, assuming good facilities for disposal of the tailings.

The narrow, canyon-like part of the stream valley, like many other rock channels in the area which are youthful as compared with the wider channels of low gradient, such as the cross-channel, contained very little gold. A shaft about mid-length of the canyon was sunk 27 feet to bedrock through rock talus and boulders, a drive of about 300 feet upstream was made, and the bottom of the channel was mined out in other places, but no pay-streak was found. The canyon contained very little gold, apparently because the only possible source was the small thickness of rocks cut through and these were not gold-bearing. On the other hand the older channels above the canyon represent stream courses of much greater age which may have contained concentrations of heavy minerals such as gold derived from the wearing away of a great thickness of bedrock. In the bedrock gravels in the old channel at the hydraulic pit there are numerous concretions of iron pyrites showing radiating structure from a central nucleus. Some of them contain minute veins of quartz which show that the concretions were formed in the bedrock and not in the gravels. They were released from the bedrock by weathering and from part of the concentrates in the stream gravels. Most of the ancient concentrates in the stream bed, however, were removed by glacial erosion, for the gravels in the channel are practically all glacial gravels, so that the pay-streak is not continuous, and the gold that remains is unevenly distributed. It is possible, however, that a rich pay-streak occurs in places in the cross-channel which appears to extend in the direction of the Thistle hydraulic pit at Eightmile lake. If it extends to the pit, of which, however, there is no very definite evidence, the thickness of the drift-filling of the valley on the present summit between the two hydraulic pits must be at least 150 feet.

The Spruce claim, owned and operated by Mr. Mugfit, is located on a short westward-flowing stream that joins Downey Pass creek about half a mile from its head. Mining in the creek bed a short distance above the rock canyon at the mouth has been carried on by ground-sluicing for a number of years and has about paid wages.

Pine Creek

Pine creek (Figure 20), of which Shepherd creek is the main branch, flows north and joins Summit creek. This is a larger stream which comes from the southeast, and which below its junction with the creek from Eightmile lake, flows east in a deep valley cut through a mountain ridge trending northwest. Pine creek, from near Shepherd creek to Summit creek, and the part of Summit creek down to the junction of Eight mile creek, flow in broad, flat-bottomed valleys, except near the junction of Pine and Summit where there are two rock "islands" between which Summit creek flows and falls 2 or 3 feet over rock. There are, apparently, buried channels of the streams on both sides of the islands. Rock outcrops occur in places along both sides of Pine and Summit Creek valleys and show that the streams flow in definite rock valleys partly filled with glacial drift and Recent alluvium. In the wide, lower part the stream has a very low grade and there is probably a considerable filling of glacial silt and swamp deposits. The valley-filling in the part above the rock islands consists of a few feet of coarse gravels and swamp muck at the surface underlain by glacial silt, which is again underlain by gravels. There is said to be no boulder clay except in places along the sides of the valley. Along the east side, in the lower part, there are extensive deposits of glacial gravels in the form of benches. Glacial gravels in the form of esker-like ridges occur along the west side of the upper part of Pine creek. The west branch of the creek, a half mile above the junction of Shepherd creek, has cut through one of these ridges which continues upstream where it is again partly cut through by another branch. The flats along Pine and Summit creeks have attracted attention as possible dredging ground, and some drilling to test the ground has been done. The discovery a few years ago of a pay-streak considerably above the level of the creek near where it cuts through the gravel ridge in the upper part of the creek has also attracted the attention of prospectors. The flats on Pine creek, including the low benches along the sides, average about 500 feet in width; those on Summit creek down to the mouth of Eightmile creek, where a narrow canyon begins, average nearly 1,000 feet. The total length of the flats is about 1 mile.

Gold was discovered on Pine creek in 1894 by John Duffy and John Shepherd and a number of claims in the stream flat and along the benches were mined by open-cut work, drifting, and ground-sluicing for a number of years. The gold was mostly in the surface gravels, which extend to bedrock only at a few places along the sides. In the valley bottom they are underlain by glacial silt and gravels. Pay-gravels were found on the creek from the road-crossing up to where the west branch, a half-mile above the junction of Shepherd creek, cuts through a gravel ridge and where a ridge of hard bedrock crosses the stream and causes a slight fall. A cross-section of eleven bore-holes 1,000 feet above the road-crossing (Figure 20) was made in 1910 for L. A. Bonner, to determine the depth of the ground, but not to determine the gold values in the ground. The borings showed that the ground in the valley flat has a maximum depth of about 70 feet, but there was one boring on the bench on the east side which is said to have been over 100 feet deep. One bore-hole, in which the casing remains, located 600 feet above the cross-section, was put down by Henry Boursin and J. Reddick. Mr. Reddick states that it was 62 feet deep and produced 65 cents in gold. Three holes were also put down by them near the lower end of the flats on Summit creek. One on the south side, about 800 feet above the mouth of Eightmile creek, was about 82 feet deep and passed through 40 feet of slum in the upper part and gravels beneath. The other two were on benches opposite Eightmile creek. The one on the south side was about 25 feet deep and the other about 38 feet. These holes are said to have shown some gold values, but much less than the hole on Pine creek. There is a rock canyon on Summit creek just below the mouth of Eightmile creek, and the ground in the wide flat of Summit creek above Eightmile creek is much deeper than at the head of the canyon. A rock basin, therefore, underlies the flat and was probably formed by a glacier moving west from the mountain slopes. The pay-streaks which may have existed in the old valley bottom must have been removed by the ice, and the pay-gravels mixed with the glacial drift. The gold on Pine creek is mostly derived by reconcentration from the glacial drift and it may be that the gold at the Thistle pit at Eightmile lake was derived by stream concentration from gravels that had been glacially transported from the basins of Summit and Pine creeks.

Mining on Pine creek during the past few years has been done only at one place on the upper part of the creek, by J. Reddick who holds two leases on the creek. Gold was discovered in coarse gravels resting on bed-rock along the west side of the creek just north of where it cuts through a gravel ridge one-half mile above Shepherd creek, and about 35 feet above the level of the creek. In the spring of 1922 mining by ground-sluicing and shovelling into sluice boxes was carried on by Messrs. Reddick, Reed, and Mason, and about $150 in gold, including one $45 nugget, was recovered from about 120 yards of gravel. The gold occurs in glacial gravels which include many large boulders in the bottom of a shallow draw between which and the creek is a low, esker-like ridge of gravels containing little or no gold. The only apparent mode of origin of the pay-streak is that the gold was derived from the glacial drift and was concentrated by ice-border drainage waters. The esker gravel deposits, which occur abundantly at the head of the valley and extend for several miles along the west side of Little valley, were probably formed in ice tunnels at the bottom of the glacier or ice-sheet, and as a rule contain no pay-streaks. The extent of the pay-streak is not known and mining can be done on only a small scale as the water available for hydraulicking is limited and the head that can be obtained is only a few feet.

Summit Creek

Summit creek, below the mouth of Eightmile creek, flows northeast in a deep, narrow valley cut through the mountain ridge trending across it, and 7 miles lower down joins Antler creek, flowing in a broad valley nearly parallel to Bear Lake valley to the east. One and a half miles below Eightmile creek the valley widens, and gravel benches along the sides are continuous even in the narrow part above, and form marked features. At about 3½ miles downstream the valley bottom is comparatively wide and is partly blocked by morainic drift ridges which have diverted the stream and caused it to cut a rock canyon on the north side of the valley. About 2 miles lower down another rock canyon occurs. The creek has a fall of about 125 feet in the first mile below Eightmile creek and the total fall in 7 miles is nearly 900 feet.

Mining on Summit creek and its two main tributaries on the north side in the lower part, Sisters (or West) creek and Hobo gulch, has been carried on intermittently since the early nineties. Mining of the bench gravels at many places in the narrow part, and also in a few places in the wider, lower part, was carried on by ground-sluicing, and two fairly large hydraulic claims and one deep-drifting claim were operated for several seasons. The upper of the two hydraulic claims was known as the Victoria, the lower as the Van Winkle. The deep-drifting, or creek claim was known as the Juanita. All three were owned by the Colonial Mines Development Company of Canada, Limited, of which F. T. Hamshaw was superintendent. Mining operations were carried on from 1899 to 1901, when the Company passed into the hands of a receiver and operations ceased. The upper hydraulic pit is a short distance below the upper rock canyon on the creek and the lower pit about three-quarters of a mile farther downstream below where the stream takes a sharp bend to the north. The Juanita claim, on which a shaft was sunk to mine the deep channel, was at the lower end of the upper hydraulic pit. The shaft is on the right side of the valley flat, which is about 175 feet wide and about 75 feet below the general surface in the vicinity of the creek. Bedrock is exposed in places on both sides of the creek flat, but is mostly concealed by gravels and boulder clay, which vary in thickness from a thin layer to 30 feet or more. John Peterson, who worked in the mine, states that the shaft was 106 feet deep to bedrock. The shaft was sunk, for the greater part of the depth, in partly cemented glacial silt which served admirably to keep out the water. Gravels containing some water were passed through near the bottom, but there was no difficulty in keeping the mine dry by pumping during the drifting operations. In all, about 575 feet of 4-foot tunnels were run from the bottom of the shaft, across the channel 175 feet and upstream, and eight blind shafts, the lowest being 30 feet, were sunk to bedrock in the channel, but it was not certain that the lowest part of the channel had been reached. Very little gold was found on bedrock in the channel and the tunnel gravels averaged only $1 to $4 a set. Water for hydraulicking was brought on the ground at the upper hydraulic pit by a ditch 2½ miles long, from Summit creek, and at the lower pit by a ditch 2¾ miles long and about 1 mile of flume and 3,600 feet of pipe. Several monitors and double lines of sluice boxes, equipped with double undercurrents, were used in each pit. Mr. Hamshaw stated[1] that in 1901 a run of thirty-two days was made and 18,000 cubic yards of ground moved on the Victoria claim, and a run of twenty-six days made on the Van Winkle claim and 32,000 cubic yards of ground washed. The material washed was mainly the surface gravels,

[1]Ann. Rept., Minister of Mines, B.C., 1901, p. 735.

averaging only a few feet thick along the sides of the valley. Several hundred feet of the banks along the channel at the upper pit were cleaned off, in places down to bedrock and in other places down to boulder clay. At the lower pit, surface gravels overlying boulder clay and glacial silt were hydraulicked.

The gold on Summit creek is, partly, fairly fine and flaky and is much flattened and worn, but is partly coarse and occasional pieces worth $6 to $9 have been found. The fact that the gold occurs mainly in the surface gravels overlying glacial drift shows that the gold was glacially transported and became concentrated in the surface gravels by stream erosion of the drift. It is true that rich spots and coarse gold were occasionally found on bedrock, but in such cases it is probable that the surface gravels extended down to the bedrock. A part of the gold, however, may have been derived locally, although this does not seem very probable as the underlying rocks are not known to be gold-bearing. Glacial striæ on the bedrock at the upper pit, and moraines crossing the valley above the hydraulic pit, show that a glacier moved down the valley and transported rock debris from its upper part. The main cause of failure in general of the mining operations appears to have been that, although the gravels in many places yielded about $1 a yard, the pay-gravels averaged at the most only a few feet in thickness, so that it was necessary to extend the mining over a large area in order to make the operations pay, and this involved considerable expense and loss of time in moving the plant. As one local mining man expressed it "the whole mining plant would have to be on wheels" in order to make the mining pay. There is no doubt that considerable areas of auriferous gravels, averaging perhaps 3 or 4 feet thick, occur along the sides of the creek, and their successful exploitation affords an interesting problem. Somewhat similar deposits have been mined in the past few years, by Chinese, lower down on Summit creek near the lower canyon, but with what result is not known. The deep channel of the creek appears to have been pretty thoroughly tested by the tunnelling on the Juanita claim, and no pay-streak that would pay to mine was found, and, if the gold was glacially transported, as seems probable, there is no reason to suppose that the deep buried channel would prove to be any richer at other places on the creek.

Valley Creek

Valley creek, or Big Valley creek as it is locally called, heads in Ninemile lake, in the northern part of the area, and flows northwest in a broad valley trending parallel to the mountain ridge on the northeast. A wagon road extends down the creek about 7 miles to the old Adams mine. There are several tributary creeks on the southwest side including: Coffee creek about $1\frac{1}{2}$ miles below Ninemile lake; Stewart creek $1\frac{1}{2}$ miles lower down; and Two-bit and Sugar creek still lower; all of which have been mined to a considerable extent, though not in recent years and not with much profit. The valley bottom down to about 2 miles below the mouth of Stewart creek averages about 1,500 feet in width, and is floored with glacial gravels and with a small amount of alluvial deposits of the present stream. The valley is deeply drift-filled and there are only a few rock outcrops along the sides. Two and a half miles below Stewart creek the creek flows in a narrow rock canyon about 100 feet deep and one-quarter mile long, and there is probably a buried rock channel alongside. Below the canyon the main valley widens, but the stream valley is narrow and is cut in drift deposits to a depth of 50 to over 100 feet. Lower down where the broad valley of West Pass creek enters from the northeast the valley is deep and is flanked on either side by broad terraces of gravels overlying glacial silt and clay. The terraces extend for several miles downstream to the junction with Willow river. The valley is of interest at the present time chiefly because it has been staked several times as possible dredging ground.

Mining of the deep channel of the creek a short distance below the canyon was carried on from 1895 to 1897 by Big Valley Creek Gold Mines, Limited, of which Major C. T. Dupont, Victoria, B.C., was president and W. Adams, superintendent. A shaft was sunk about 37 feet on the left bank of the creek and about 700 feet of tunnel was run across the channel and upstream; an incline was also made, as the shaft was not deep enough to reach the bottom of the channel. Some coarse gold was found, but is said to have been very unevenly distributed, and no regular pay-streak was found. All the materials filling the channel were gravels and some difficulty was experienced in draining the ground. A shaft about 80 feet deep was also sunk in the bank on the south side to test the ground for hydraulicking. Considerable mining by ground-sluicing was done by Chinese on the gravel benches a short distance below the Adams shaft, where surface gravels a few feet thick overlie glacial silt and clay. Mr. L. Muller, who examined and weighed the gold obtained by the Chinese, states that it amounted to 53 ounces, and was about the size of flaxseed. Some drilling to test the ground on Big Valley near the mouth of Stewart creek was done in 1912 by T. Dickerson, and in 1913 by J. T. Towers. Three holes were put down in 1912, two at the mouth of Stewart creek and one lower down near the road crossing of Valley creek. The upper holes were 30 and 60 feet deep and the lower one about 80 feet, but not to bedrock. The gold values are said to have amounted to 24 cents per cubic yard in the lower hole, but only 2 to 10 cents in the upper holes. Three holes were put down by Towers and the values are said to have been less than those obtained by Dickerson.

The ground in Big valley probably exceeds 100 feet in depth, or too deep for the bottom to be reached by dredging, but there is a possibility that an interglacial pay-streak occurs in the valley and that there is some gold in the surface gravels along the sides. There does not seem to be much gold in the surface deposits in the valley bottom down to the canyon. There are pay-gravels on the benches below the canyon, but whether they are sufficiently extensive to pay for mining on a large scale is not known.

Burns Creek

The lower part of this creek is shown on Figure 21. It heads in Burns mountain, flows north into Slough creek, and is noted for the number and complexity of the rock channels in the lower part of its course and for the coarse gold that was found on the upper part of the creek nearly to its source, as well as in places on the lower part. Near the foot of the steep part of the mountain slope the creek turns abruptly to the right and flows for 800 feet through a partly drift-filled rock canyon. Below the canyon the creek flows across rock benches for a short distance and, lower down, near its junction with Slough creek, occupies a drift-filled valley which, however, is not deep except near the junction. Opposite the head of the canyon, and extending downstream in line with the upper part of the creek, is a drift-filled channel down which the present stream has been diverted to a ditch carrying water to the Ketch hydraulic mine on Devils Lake creek. A third rock channel in which a small pond occurs, and down which the Burns

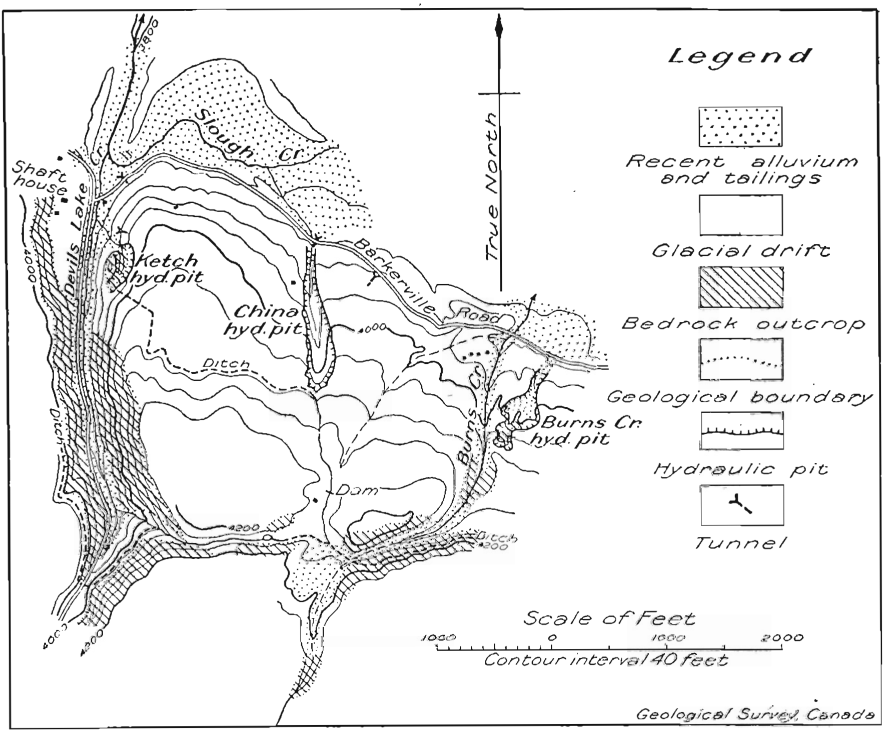

Figure 21. Burns and Devils Lake creeks, Cariboo district.

creek water may also be diverted, extends through to Devils Lake creek and is nearly opposite the upper end of Burns Creek canyon. It is impossible to tell just how all these channels originated and what are their relative ages, but it would appear that the channel through Burns Creek canyon, evidently a new one because it is partly drift-filled, is also older, so far as the bedrock channel is concerned, than the buried channel leading directly downstream, for the latter is deeper. This channel appears to trend towards the head of the China hydraulic pit, but its exact course is not known. It may lie farther east or there may be several buried rock channels in the lower part, where the old stream crossed the rock benches. The benches are marked features, although they are largely concealed by glacial drift which has also filled and concealed the old rock channels. The depth to bedrock in the China hydraulic pit, and the depth of the valley cut in drift and heading near the dam above the head of the China pit, shows that rock channels are cut down through the rock benches. None of the channels appears to be graded to the deep valley of Slough creek.

Mining on Burns creek was started in the early sixties and was carried on for many years. The channel in the upper part and down through the canyon to the lower end of the benches was mined partly by drifting, but mostly by open-cuts extending down to bedrock. Drifting of the channel at the China hydraulic pit, or Lake gulch as it was formerly known, was done in the seventies by Hugh Brown, Harry Gillis, J. C. Beatty, and other local miners. A tunnel was run in from below the road and the workings extended to beyond the head of the present pit. There is an old air shaft, probably connected with the workings, on the right side above the head of the pit. The driftings along the channel, which is generally regarded as the old outlet channel of Burns creek, are said to have paid 25 ounces to the set in the lower part from 50 to about 200 feet above the road. In the upper part the pay was much less. Later, hydraulicking along the course of the channel was carried on for many years by Chinese. The work is said to have about paid expenses. Only a small water supply from Burns creek was available and the bank was high and composed mostly of boulder clay overlain by a small thickness of gravels. A tunnel just above the road about 700 feet east of the pit was run, about 1900, by Robert Anderson. The tunnel reached bedrock at about 100 feet, but no gold was found. The bedrock at the end of the tunnel is considerably higher than in the channel at the mouth of the China pit. This shows that there is probably a ridge or bench of bedrock beneath the drift on the east side of the pit and the valley cut in drift between the pit and Burns creek shows that a depression in the bedrock occurs beneath it. Hydraulicking of the bench deposits along the east side of Burns creek, in its lower part, was carried on during parts of the hydraulic seasons from 1900 to 1903 by the Cariboo Exploration Company, Limited, of which S. Medlicott was manager for a time and later John Hopp. Water was brought from Jack of Clubs creek by a ditch 4 miles long. The ditch was 4 feet wide at the bottom and 7 feet at the top and had a capacity of 1,600 miner's inches. The water under a head of about 280 feet was brought to the pit by 2,400 feet of pipe-line. Two monitors, a No. 2 and a No. 6, were used. Hopp reported[1] in 1902 that 36,000 yards of material had been handled during the season, and in 1903 that a run of only seventeen days was obtained because of the shortage of water, but that the gravels contained satisfactory values in gold. The total amount of material removed from the pit was about 60,000 yards. It was intended in 1903 to enlarge the plant, for apparently it was decided that the operations could not pay unless a better water supply were available, but no further work was done. The grade of the bedrock in the pit is 10 to 20 per cent and there are fair facilities for disposal of the tailings. The deposits are 10 to 30 feet thick, or possibly more in places, and consist of surface gravels up to 10 or 15 feet thick underlain by boulder clay.

[1]Ann. Repts., Minister of Mines, B.C., 1902, p. 123; 1903, p. 63.

Numerous boulders, many of which are too large to be put through the sluice boxes without blasting, occur in the surface gravels and occasionally in the clay. The gold is said to occur mainly in the surface gravels and on the clay, but probably some occurs also on bedrock. The average tenor of the gravels is not known and would be difficult to estimate over a large area without extensive testing of the ground, because of the irregularity and lack of continuity of the pay-streak. There is little doubt, however, that comparatively rich pay-streaks occur locally on the benches that border Burns creek in its lower part and extend to Devils Lake creek. The area is an attractive one because Burns creek is known to have produced large amounts of gold; and gold-bearing quartz veins from which the gold was originally derived are known to occur in the upper part of the basin of the creek. The main cause of failure of the hydraulic operations of the Cariboo Exploration Company appears to have been that, although Jack of Clubs creek at the intake of the ditch has a low water flow of nearly 100 miner's inches, little or no water was delivered by the ditch in the dry season because it is excavated for long distances in porous gravels into which the water seeped. Whether there is sufficient payable ground for hydraulicking to justify the expense of obtaining ample water can probably be determined only by further prospecting. Several prospect pits and shafts were put down in the vicinity of the hydraulic pit, by the Cariboo Exploration Company, but the results of these tests are not known. How far upstream the old driftings in the China pit extended is not known, but they probably extended as far as there was any pay. It is also uncertain whether these workings were in an old channel of Burns creek, although this seems probable, and whether another channel may not exist between it and the present Burns creek.

Olally Creek

Olally creek lies between Burns and Jack of Clubs creeks and flows north into Slough creek. The creek occupies a narrow, steep valley cut, for the most part, in bedrock above Jack of Clubs ditch. In the lower part it flows across drift-covered rock benches and has a comparatively low gradient. Several shafts were sunk to bedrock in the lower part, a few hundred feet above the junction with Slough creek, and several tunnels were run. One, known as the St. Clair tunnel, started near the lower end. Two others, run by Gust. Lange, started a short distance below the ditch. The materials found on bedrock in the shafts and tunnels are said to have been glacial muddy gravels carrying little or no gold. Most of the ground along the creek was leased by the Cariboo Exploration Company in 1899. In recent years no work has been done on the creek.

Devils Lake Creek

This creek (Figure 21) 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 basins are probably, also, in part, rock basins formed by ice-erosion. In the lower part the valley bottom is filled with glacial drift and alluvial deposits to a depth of about 50 feet below the creek level. A ridge of morainic deposits 40 feet high occurs on the west side, in the lower part where the valley widens. It extends upstream for 1,000 feet and the deep channel of the creek is beneath this ridge. The valley, although narrow, was widened and deepened—if not largely formed—by a valley glacier. This is evident from the extensive morainic deposits, composed mostly of angular fragments of rock similar to that forming the sides of the valley that occur at the mouth and extend nearly across, and for some distance down, Slough Creek valley. These deposits are amoung the latest of the glacial deposits and, therefore, were formed during the closing stages of glaciation. The volume of the deposits is sufficiently great to fill a considerable part of the valley.

Gold was found in the early days only at a few places high up along the sides of the creek, on bedrock which outcrops below the road near the junction of Slough creek, and in the surface gravels near the mouth of the creek. Several tunnels were run beneath the morainic ridge and at other places near the mouth of the creek. About 1910 H. H. Jones and H. Foster put down a shaft on the bench, on the left side at the mouth (Figure 21), for the purpose of mining the deep channel. The shaft had two compartments, one with a 12-inch Cornish pump. Two boilers, one obtained from Slough Creek mine, were used. The shaft is 95 feet deep, the collar being 45 feet above the level of the creek. Some drifting was done from the bottom of the shaft, but, apparently, little or no gold was obtained. In 1898 and 1899 the Devils Lake Gold Mining Company ran a tunnel about 400 feet long, in an attempt to reach and mine the deep channel beneath the lowest lake in the upper part of the valley. The tunnel was partly in bedrock. When it broke out from the bedrock the deepest part of the channel was not reached, and as the tunnel would have had to be considerably extended to reach the lowest part, the work was abandoned. Recently somewhat similar attempts to mine the deep channel beneath the upper lake have been made. The fact that the valley, especially in its upper part, was formed in part by valley glacier erosion, does not favour the view that payable deposits of placer gold occur on bedrock in the valley bottom; for even if gold were released from the bedrock, by the ice grinding up and plucking out masses of it, there could have been little or no chance for concentration of the gold into pay-streaks by water action, except by erosion of the drift deposits at the surface. No gold-bearing veins from which the placer gold may have come are known to occur in the basin of the creek, but they may occur, for the rock is exposed only in places. The gold found in the bed of the creek near the mouth was probably derived by stream erosion of the drift. The gold found high up on the benches may have been transported along with the glacial drift and concentrated by streams flowing along or from the ice.

The Ketch hydraulic mine is located on the right bank of Devils Lake creek near its mouth. The property is owned by the Houser brothers. 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, but is sufficient for a No. 2 Monitor for only six to eight weeks in the early part of the season. A larger supply could be obtained if a good ditch were constructed. The ground along the present ditch is in places very porous, especially above the head of the old China pit, and much of the water in the upper part of the ditch is lost in the dry season by seepage. A head of about 100 feet at the hydraulic pit is obtainable. Because of the character of the ground it is difficult to estimate the amount of water that can be made available by ditches. 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, so that there are some possibilities for further hydraulicking. A chief difficulty, as already stated, is the lack of water. In 1923 about 170 ounces of gold were obtained, but in 1924 the returns were only about 11 ounces. Water was available for hydraulicking in 1924, however, for only about six weeks

Coulter Creek

Coulter creek (Figure 22), or Calder creek as it is sometimes called (it is reported to have been named after Harry Calder who discovered it), rises on the southwest slope of Island mountain and flows into Slough creek. The creek was mined in the early days along a stretch of about 1,000 feet, beginning about one-half mile up from the mouth. Along this stretch the depth to bedrock was only a few feet, or the creek flowed on the bedrock. In the lower part the bedrock is deeply buried. A narrow canyon cut in bedrock occurs about 3,000 feet up from the mouth and is bordered on the southeast side by a buried channel which extends upstream about 400 feet to the wide part opposite the first tributary. The channel was mined by Chinese, by means of a tunnel started at the lower end, at creek-level, but whether it paid for working is not known. The creek as a whole is said to have produced comparatively little gold. Mining on

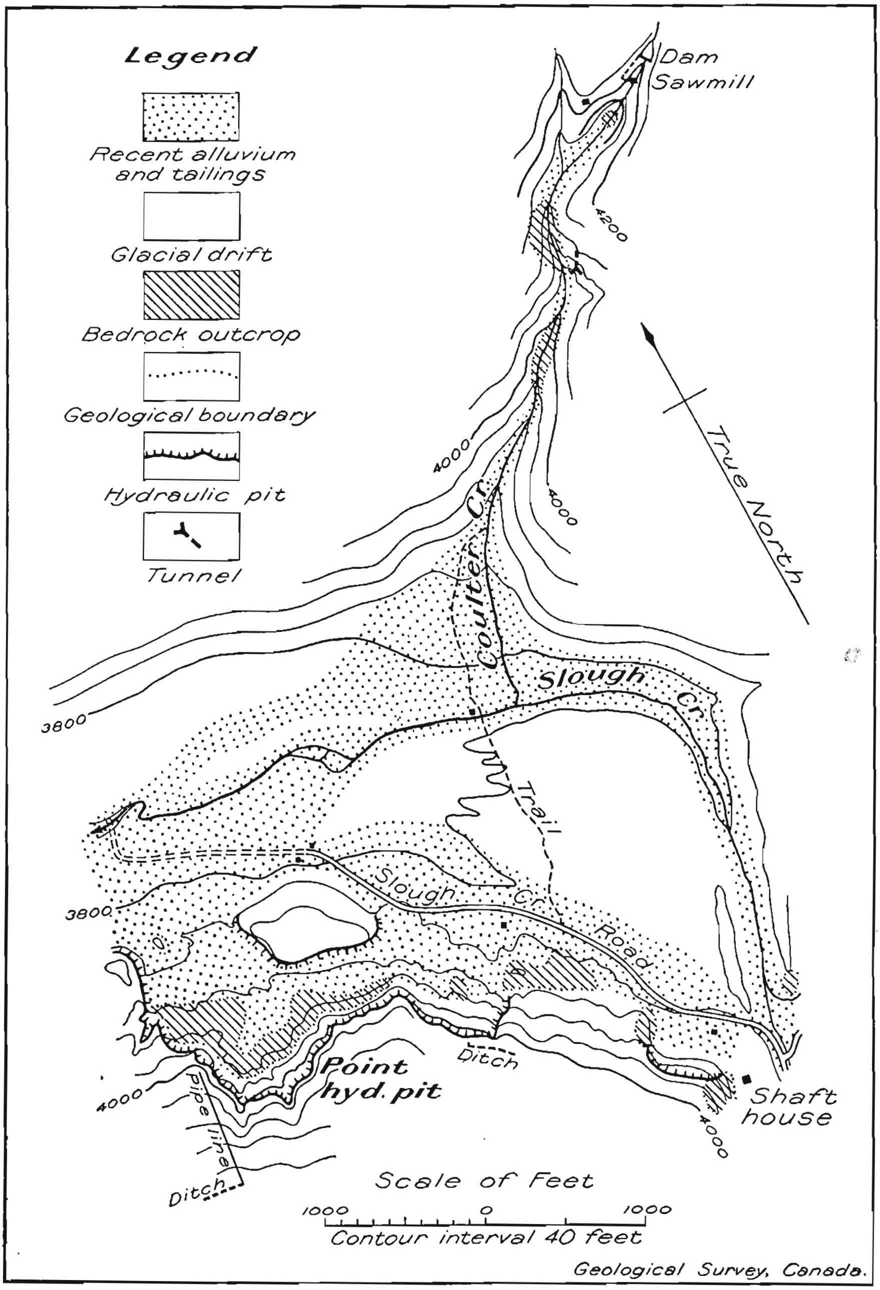

Figure 22. Parts of Coulter and Slough creeks, Cariboo district.

the creek during the past few years has been carried on by Julius Powell (Coulter Creek Mining Company) who has installed a complete, small hydraulic plant, including a dam and ditch, a small sawmill, operated by a Pelton wheel, and an electric lighting plant. The plant is located about 700 feet above the mouth of the first tributary creek. A No. 2 monitor with 4-inch nozzle is used, the head of water being about 100 feet. About 80 miner's inches would be available on the average throughout the hydraulic season if the flood water could be stored. The present dam permits of storage of water for work at intervals during the dry season, but the flood water can not be conserved to any great extent. The sluice boxes have an 8-inch grade and twenty-six to thirty 12-foot lengths are used. As the creek has a fairly high gradient there is little difficulty in disposing of the tailings. The bedrock was reached in the hydraulic pit in 1923 and is apparently in the deepest part of the channel. Some gold values were found in a small thickness of gravels resting on the bedrock. At the head of the pit in the valley bottom the bank is about 40 feet high and consists mostly of glacial gravels with some silt and clay. As the sawmill is located only about 100 feet above the head of the pit and the dam a short distance farther up, they will have to be removed if operations are continued. There is a considerable stretch of the creek above the plant which has not been mined, but whether it will pay for hydraulicking is speculative, as no adequate testing of the ground has been done. The hydraulic operations during the past few years are said to have about paid expenses.

Slough Creek Mine

Slough Creek mine (Figure 23) is situated in the broad valley of Slough creek opposite the mouth of Nelson creek and is reached by a road turning off from the main highway at the mouth of Devils Lake creek. Although no mining has been attempted since 1907, the mining operations and development work are here somewhat fully described because of the interesting problems involved, and because it has recently been proposed to re-drill the ground to determine the depths and values. The ground is known to have a maximum depth of about 287 feet and mining of the bedrock gravels was attempted by sinking a shaft in bedrock at the north side of the valley and driving a tunnel beneath the deepest part of the channel, into which openings were made by upraises from the tunnel. But, although pumping, to drain the ground and thus permit of mining of the bedrock gravels, was carried on almost continuously for over five years it was not found possible to reduce the water pressure except slightly. Why this was the case forms one of the most interesting problems in connexion with the mining operations. Some testing of the ground for gold values was done by drilling and by determining the amounts of gold in the small quantities of bedrock gravels obtained by breaking into the channel at a few places, but whether the gravels will pay for mining if the ground be drained was not definitely settled. The drilling was done with an hydraulic jetting machine which proved fairly efficient in testing the depth of the ground and the character of the strata passed through, but was not considered efficient in determining the gold values in the gravels, and only small quantities of gravels were obtained in the drifting operations. The ground was supposed to be rich because Nelson creek, which empties into Slough creek at the mine, was known to have produced in the early days large amounts of gold—variously estimated at $1,000,000 to $3,000,000—and coarse gold was reported to have been found on bedrock as far down the creek as mining by drifting could be done, that is to the level of a drain tunnel brought up from Slough creek. The benches

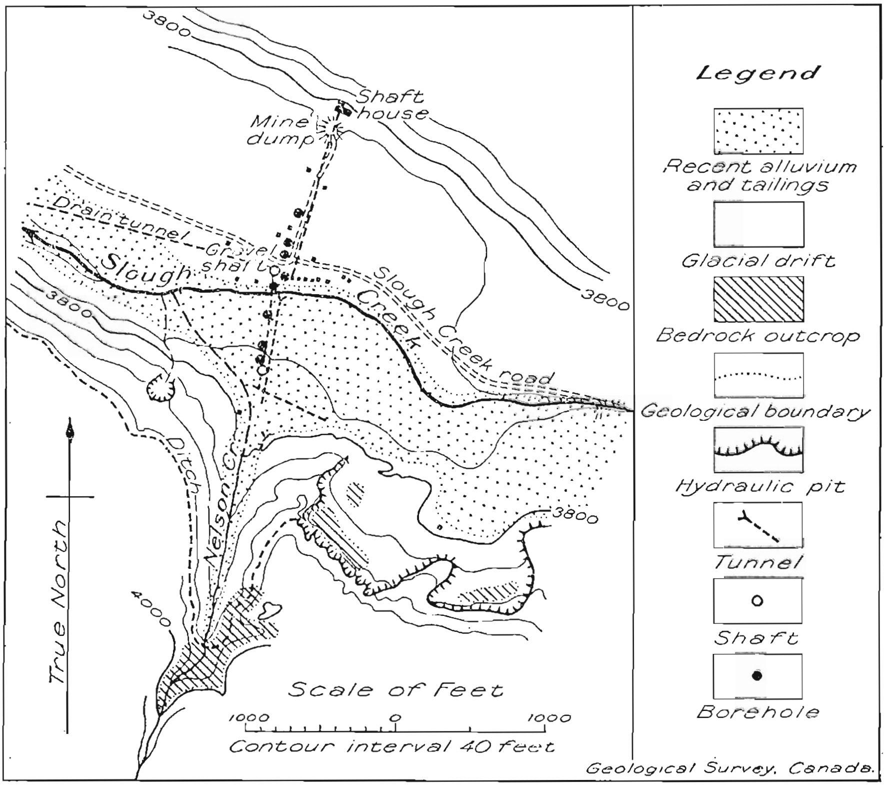

Figure 23. Slough Creek mine, Cariboo district.

along the south side of Slough creek above the mouth of Nelson creek were also known to have produced considerable quantities of gold, and, as the higher benches do not extend below the mouth of Nelson creek, it seemed reasonable to suppose that they have been cut away and that the deep ground in Slough creek opposite the mouth of Nelson creek has been enriched by the gold from the benches. Probably nearly $500,000 in all was spent in attempts at mining the deep gravels at Slough creek, with practically no returns. The following account of the mining operations is based on information obtained from Mr. John Hopp, manager at the mine for several years, from Mr. Laurent Muller, foreman, and from the reports of the

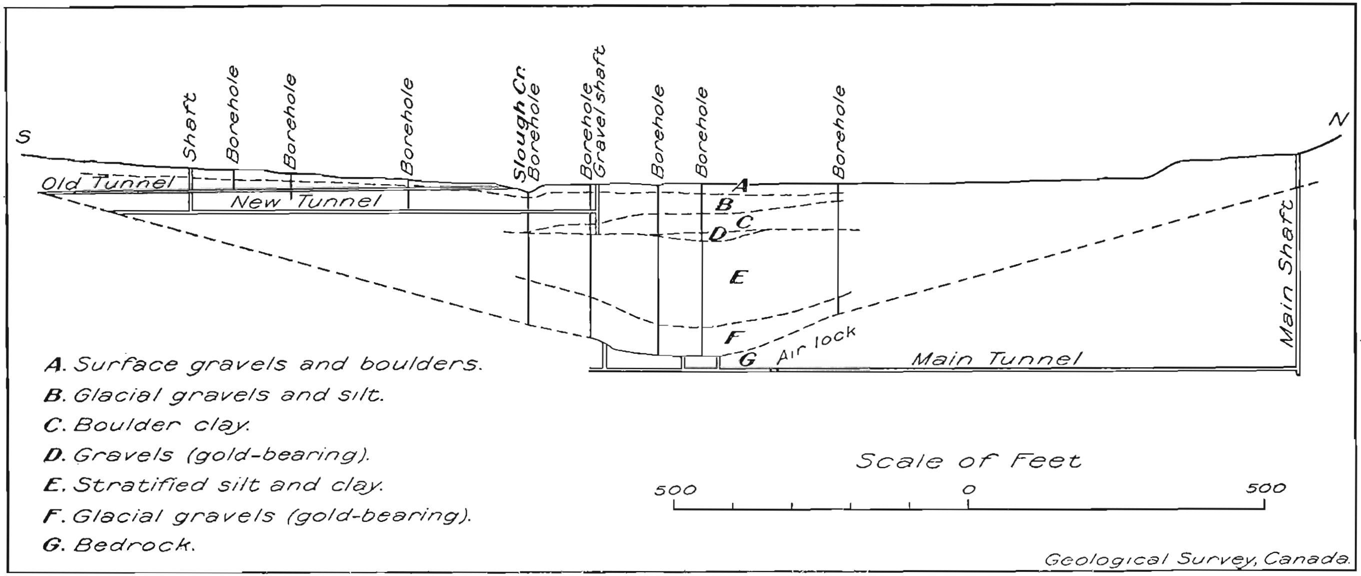

Figure 24. Cross-section of Slough creek at Slough Creek mine, Cariboo district.

mine managers of the several companies that carried out the work. Figure 23 shows the topography and surface geology of Slough creek and the lower part of Nelson creek at the mine, also the locations of the principal bore-holes, shafts, and tunnels. A cross-section of Slough creek at the mine is shown in Figure 24. The subdivision of the surface deposits overlying the bedrock, as shown on the cross-section, is based on the drilling records as interpreted by the present writer and is somewhat generalized, as only a few of the drilling records are available.

Mining development work at Slough Creek mine began in 1892 when Charles Ramos, representing a company which had acquired a lease of part of the valley bottom, put down a number of bore-holes and sank a 30-foot shaft near the creek on the north side. The maximum depth of the channel was determined at 246 feet, but this was later found to be incorrect. Three bore-holes south of the creek (Figure 23), the deepest being only 45 feet, were supposed to have reached bedrock, but it was proved later, when a tunnel was run from the "gravel" shaft on the north side of Slough creek to the mouth of Nelson creek, that large masses of rock or boulders were mistaken for the bedrock and that the depth to bedrock at these places is much greater. In sinking the gravel shaft trouble was experienced because of the excessive pressure of the ground water. To overcome this difficulty a drain tunnel 2,150 feet long was run. This, however, tapped the shaft at a depth of only 37 feet from the surface. The drilling had apparently shown that clay occurred at a depth of 45 or 50 feet and it was expected that once the clay was reached the surface water could be shut off and the shaft sunk through the clay to bedrock. No impervious clay, however, was found, nor was it struck at a depth of 84 feet, which was the maximum depth to which the shaft was subsequently extended. In 1895, the Slough Creek Mining Company, Cariboo, of which W. H. Fife was president, took over the property and continued the development work. Further boring was done and the maximum depth of the channel determined at 287 feet. A tunnel, known as the New tunnel, was started from the 37-foot level in the gravel shaft and extended for about 825 feet to bedrock in the lower part of Nelson creek, the bedrock at the end of the tunnel being about 80 feet below the surface. A hoisting shaft was put down at a point about 125 feet from the end of the tunnel and a crosscut at the end of the tunnel was driven for 600 feet. One set of posts in the crosscut rested on bedrock all the way and the bedrock was found to be pitching steeply into the valley of Slough creek. Considerable difficulty was experienced in running the tunnel because of the wet, caving character of the ground and because of the large boulders encountered. It was found necessary to clean out the old drain tunnel 30 feet above the new tunnel and to run a "balloon" drive between the two to carry off the surface water. The tunnel was run for the purpose of mining the bedrock gravels in the lower part of Nelson creek and with the intention of sinking a shaft in the bedrock and drifting out into the channel of Slough creek. Apparently no very high values were found in the bedrock gravels of Nelson creek and the character of the ground prevented sinking a shaft in the bedrock. In 1898 the property was acquired by the Incorporated Exploration Company, Limited, of London, England, which later became "Slough Creek Limited," of which William Thompson was managing director and consulting engineer, and

John Hopp, local manager. Additional boring was done, and the maximum depth of the ground verified. It was then decided to sink a bedrock shaft on the north side of the valley, and drive a long bedrock tunnel from the bottom of the shaft to intercept the channel. A small shaft was sunk to water-level and a tunnel driven 104 feet into the hill to bedrock, which proved to be 50 feet from the surface. The main shaft, which has two hoisting compartments and one pumping compartment, was then sunk, the depth from the collar of the shaft to the floor of the main tunnel being 362 feet 4 inches. The elevation of the collar of the shaft is 50 feet above the level of the surface of the ground at the deepest bore-hole. The main tunnel is 8 feet wide and 7 feet high and was finally extended 1,230 feet from the bottom of the shaft. The grade of the tunnel is 0·2 per cent. An air lock was placed in the tunnel at a distance of 889 feet from the shaft. It consisted of two air and water-proof steel doors 15 feet apart set in steel and concrete bulkheads, openings being provided by means of pipes for compressed air, ventilation, and drainage. It was designed to withstand a maximum pressure of 100 pounds to the square inch. It proved efficient for pressures of 45 to 50 pounds which were frequently used, but the doors bulged when a maximum pressure of 75 pounds was applied. Its purposes were to prevent a heavy flow of water and mud into the tunnel when openings were made into the channel, to prevent influx of water when gravel was being removed, and in case of accident to the pumps to prevent flooding of the mine. The pumping plant consisted of two Worthington pumps of an estimated capacity of 500 gallons each per minute. The pumps were placed in a pump chamber 28 feet by 23½ feet by 8 feet high, cut in the bedrock at the bottom of the shaft, the floor of the chamber being 4 feet 6 inches above the level of the floor of the tunnel. The power plant consisted of four 40-horsepower return tubular boilers using wood as fuel. The complete plant was installed in November, 1901, and attempts at draining the ground and mining the gravels began shortly afterwards and continued with few interruptions until September, 1907. In 1905 a new company, known as The Slough Creek Gravel Gold, British Columbia, was formed to operate the mine. Sir James Bevan-Edwards was president and J. D. Kendall of London, England, consulting engineer. Archibald Russell and Archibald Stark were local managers during parts of 1905, Bertram Mellon was manager in 1906, and H. Waters in 1907. In May, 1906, the company went into liquidation and a new company was formed under the name "Slough Creek, Limited." The reconstruction of the company furnished a working capital of £40,000.

The mining operations during the period from December, 1901, to September, 1907, consisted very largely of driving crosscut tunnels and inclined upraises to the old channel from near the end of the main tunnel. These were intended to drain the gravels and relieve the pressure sufficiently to permit of mining them. Several hundred feet of drifts were run both upstream and downstream from the main tunnel, many bore-holes were put up through the bedrock to the gravels, and many small drives extended to the channel. It was found, however, even in the case of 2-foot drives, that on breaking into the channel, so great a pressure developed, either suddenly or gradually, that the timber would be crushed and the drive would have to be closed with a bulkhead and abandoned. During the whole period, apparently only a few yards of the channel gravels were obtained for testing of the values. Careful records were kept of the flow of water and of the water pressure. All the water coming into the mine was forced to flow over a weir placed in the air lock and was thus measured. The water pressure was measured by placing gauges on pipes leading from bore-holes that extended from the tunnel into the channel gravels. The water pressure varied from 85 to 107 pounds per square inch, but usually remained at about 98 pounds, and was only occasionally reduced to 85 or 90 pounds. The flow of water for two or three years after the first openings into the channel were made in 1902 varied between 500 and 775 gallons a minute. When it began to be realized that the draining of the ground was going to prove a very slow process, an effort was made to increase the flow of water by making fresh openings into the channel. The flow was increased for a time in 1905 to 812 gallons a minute, which was about all the pumps could handle. During part of 1906 it fell off to 730 gallons a minute and in January, 1907, was only 660 gallons a minute. In February, 1907, two new boilers and a direct-acting hoisting engine were installed to operate two counterbalanced water boxes slung on cables in the two hoisting compartments of the shaft. The boxes were made too large for the plant, but were cut down and had a capacity of 340 gallons a minute when run at full speed, but only 225 gallons when operated safely, for trouble was experienced in attempting to operate the direct-acting engine at high speed. With this auxiliary pumping plant the water flow from the mine was increased to 970 gallons a minute, but the pressure remained at about 90 pounds. The drain tunnel was also cleaned out and extended upstream to cut off the surface water. In August, 1907, a two weeks continuous run at capacity was made and as this had no appreciable effect on lowering the pressure operations were suspended on September 4. It was proposed to develop hydroelectric power for operation of the mine, by damming Willow river at the rock canyon a short distance below the junction of Slough creek, by bringing water by means of a tunnel from Jack of Clubs lake, or by bringing the water in ditches some distance down Willow river and establishing a power plant there, but nothing further was done. Four of the boilers and much of the mining machinery remain at the mine. The pumps were left in the pump chamber. The shaft is open and filled with water up to the groundwater-level 57½ feet from the collar of the shaft. The timbering of the shaft is probably fairly sound up to the water-level. The property is said to be held at the present time by Lady Bevan-Edwards.

The reason why the ground could not be drained nor the pressure materially lessened, although pumping at the rate of nearly 1,000,000 gallons a day was carried on almost continuously for five years, cannot be definitely determined because all the factors which must be taken into consideration are not known. There is evidence, however, which appears to indicate that the water pressure at the bottom of the channel was communicated by a column of water that filled the interstices of the gravel, etc., and extended up to the groundwater-level, that is, to the level of the drain tunnel, and that, therefore, a constant supply of water was furnished by the surface drainage waters. The vertical distance from the floor of the drain tunnel to the deepest part of the channel is 250 feet. A column of water of this height would furnish a pressure of 108 pounds to the square inch. The pressure gauges located in the tunnel, the floor of which is 13 feet lower than the lowest part of the channel, usually registered about 98 pounds, but occasionally as high as 107 pounds. It is improbable that they registered the full pressure because of relief of pressure owing to the flow of water from the channel into the mine and because of leakages in the bore-holes. It was frequently noted during the operations that when a copious flow of water was obtained the pressure decreased for a time. If the pressure came from a column of water extending up to what was supposed from the drilling records to be the base of the boulder clay, 83 feet from the surface, it would have amounted to only 88 pounds to the square inch. Moreover, it was shown by the sinking of the gravel shaft that no impervious bed of boulder clay existed at this point down to a depth of at least 84 feet, although the presence of boulder clay was apparently shown by the bore-holes north of the shaft. The new tunnel driven from the gravel shaft south to bedrock at the mouth of Nelson creek is said to have passed through a bed of boulders and wet, muddy gravel all the way. The surface gravels and boulders north of the creek are mostly morainic materials. South of the creek they consist of Recent stream deposits and tailings. They are underlain by silty glacial gravels in places, but do not extend across the valley. The great bed of material, 150 feet thick in the central part of the valley, referred to in the drilling records as clay, is judged by the present writer to be glacial stratified silt and clay (slum) because of its uniform character and because of the absence of stones or boulders. It is evidently water-saturated, for it was found impossible to sink a shaft, but probably the downward passage of water is very slow. It seems doubtful whether the water pressure in the channel was communicated through it. The basal gravels, however, extend for some distance up the bedrock sides of the valley and the water pressure may have been communicated through them. The pressure was evidently due to the height of the column of water and not to the weight of the overlying materials, for, if the materials had tended to settle, the pressure would have been greater. The real difficulty in draining the ground was probably due to the fact that the boulder clay does not extend across the valley, for no serious difficulty was met with in draining the ground at the La Fontaine mine on Lightning creek, where boulder clay does extend across the valley. It may be that the basal gravels are very porous and that, therefore, the hydraulic gradient in them is very low. It is generally assumed in mining operations of this character that the amount of ground to be drained is that occupying an inverted cone, the volume of which depends upon the height of the water column in the ground (beneath an impervious stratum, if one exist), and the inclination of the sides of the cone or the hydraulic gradient. Ordinarily the amount of ground to be drained is not very great, and even in the present case there seems no reason why the pumping operations should not have been successful unless the basal gravels are porous and are supplied with water from the surface. A fact which seems to show that water does have access to the gravels is that in August, 1923, the surface run-off from Slough Creek basin, as measured by a weir at Slough Creek mine, averaged only one-sixth of the precipitation over the basin, whereas in other basins in the area it averaged one-quarter to one-fifth. There is no way of determining what quantities of water would have to be pumped in order to drain the ground, but it is evident that a much larger pumping plant than the one used would be required.

Pay-gravels were struck in one or two of the bore-holes north of the creek at a depth of 83 feet from the surface. The gravels have a thickness of 12 or 13 feet, but what the values amount to is not known. They evidently form an interglacial pay-streak, for they are overlain and underlain by glacial deposits. The width of the pay is probably not over 100 feet, for it does not seem to have been struck in more than one or two of the bore-holes. The gravels may be of some importance as a dredging possibility, for they probably extend for some distance up and down stream from the mine, but the values in the gravels would have to be fairly high to pay for dredging, because of the nearly barren overburden. The gold values in the gravels resting on bedrock in the deepest part of the channel, according to the few tests made by washing the gravel obtained by breaking into the channel, were found in one test to amount to $7\frac{1}{2}$ pennyweights a cubic yard and in another nearly one ounce to the yard. In both cases, however, less than a yard of gravel was tested. These values are much less than those found in the early days in the bed of Williams creek and at other places in the region, and unless the true values are higher and extend throughout a considerable thickness of the bedrock gravels, it is doubtful whether the gravels would pay for mining under present conditions, assuming that it be possible to drain the ground sufficiently to permit of mining. It is true that mining of bedrock gravels by drifting was done twenty-five years ago at La Fontaine mine, on Lightning creek, at a cost of $3 or $4 a yard (actual mining cost not including overhead), but at that time fuel and wages cost about half what they do now. The bedrock gravels have considerable thickness, but if they are sufficiently porous to permit of circulation of water through them it is probable that the gold in them would be concentrated near the bedrock, for it would tend to work down through the gravels. The gravels, judging by the samples said to have been obtained from the underground workings and from the descriptions of them in the managers' reports, are evidently glacial gravels or "cobble-stone wash" (as they are sometimes described by the miners) and differ from the "flat wash" in which the rich pay-streaks in the district are usually found. The fact that the bedrock gradient of the lower part of Nelson creek from where it dips off into the valley of Slough creek down to where it joins the deep channel of Slough creek, is much steeper than in the part higher up, shows that the bedrock valley of Slough creek was probably deepened by glacial ice erosion. If there had been no ice erosion of Slough Creek valley Nelson creek would have been graded to it and would have had a steeper slope in its upper part than in its lower part, unless a hard rock ridge, of the presence of which there is no evidence, caused rapids or falls in the lower part. Streams, normally, have steeper gradients in their upper parts than in their lower parts because the volume of water is less in the upper parts and requires a steeper slope for its flow. It is, therefore, improbable that prelacial gravels occur in the bottom of Slough Creek valley. The gravels that occur may be either glacial gravels formed by streams issuing from ice tongues that lay in the upper parts of the valley or gravels formed by stream erosion of glacial deposits and partly of the bedrock. They are known to contain some gold, but whether sufficient to pay for drifting—the only possible method—can be determined only by drilling. In order to drift the ground would have to be drained by pumping. A drain tunnel is, apparently, out of the question as it would have to be 6 or 7 miles long.

Slough Creek Benches

A series of rock benches overlain by drift deposits (Figures 22 and 23) 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. Comparatively little mining has been done during the past few years owing to the increasing difficulties in making the operations pay. These difficulties are mainly the very thick drift deposits on the south side of the rock bench; the steep, high bank; and the disposal of the tailings. 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 old channel of Nelson creek and the benches below it were mined chiefly twenty to twenty-five years ago by the Qwong Lee Company and by other Chinese companies. Water under a head of about 100 feet was obtained from Nelson creek. The ground for the most part was only 10 to 20 feet deep and has been pretty well mined out. At the present time there are three hydraulic properties (bench leases averaging about 1,500 feet in length) owned by Chinese. The upper one is known as the Sing Dang, the middle one as the Point, and the lower as the Dang Sing Dang. The major operations in recent years have been carried on by the Point Hydraulic Mining Company, Limited, on the Point ground. The company also holds an interest in the Dang Sing Dang. The property is owned by Loo Gee Wing, Vancouver, and includes a lease on Montgomery creek, with which the leases on Slough creek are consolidated. 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. In 1913 the plant was enlarged and hydraulicking on a fairly large scale was carried on profitably for several years, under the direction of Joseph Wendle. The total investment for mining plant and ditches was about $75,000. 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 per 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 elevation of the water in the ditch at the pressure box is 4,186 feet and the elevation of the bedrock in the pit 3,900 to 3,950 feet. There is thus an average head of about 260 feet. Water is brought onto the ground above the Point claim by a ditch which leads from a creek heading in a small lake near Burns creek and crosses Devils Lake creek by means of a trestle. The headwaters of Devils Lake creek are also brought into the ditch. The drainage area supplies about 140 miner's inches. Water from Burns creek was formerly brought to the ditches by a ditch to the small lake a short distance west, but the Burns Creek water has been used for the past few years at the Ketch mine near the mouth of Devils Lake creek. The elevation of the ditch at the pressure box is 4,033 feet or 153 feet lower than the Point ditch. The ditch cannot be extended much farther and cannot be brought onto the Point ground because of the high, steep bank of the hydraulic pit. It was proposed at one time by the Point Company to bring water from Lightning creek, by way of the pass at the head of Devils Lake creek, but the project was abandoned as being too costly.

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. An outcrop along the Point ditch near its end limits the width of the benches at this point and shows that a steep rock slope must exist. 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 and on the lower 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 inter-glacial 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 mode of origin of the bedrock benches and the placer gold on them is not very clear. The rock benches were probably formed partly by stream erosion previous to the cutting of the deep valley of Slough creek and were later modified by glacier ice erosion. The bedrock on the benches shows no definite evidence of glacial erosion, although the rock is sufficiently hard in places to have preserved glacial striæ. On the other hand all the deposits overlying the bedrock appear to be glacial in origin. It is probable, therefore, that the ice eroded the bedrock, at least to some extent, and removed or mixed with the glacial drift the old stream gravels, if such occurred, on the benches. The benches must have been formed before the deposition of the glacial drift and the fact that some of the higher benches slope upstream seems to show that they were formed by a system of drainage waters different from the present system and from the glacial drainage. The placer gold was probably concentrated in pay-streaks on the benches in pre-Glacial time; it was later mixed with the glacial drift and was reconcentrated by stream erosion of the drift. A part, also, was probably transported along with the glacial outwash gravels. The significance of these partly hypothetical considerations is that the gold is likely to occur in paying quantities only in places where gravels extend down to a false or the true bedrock. Some gold may occur in the gravels between the two boulder-clay sheets, but where clay rests on bedrock there is likely to be little or no gold beneath the clay. The gold is probably very unevenly distributed over the benches, but there is no reason why pay-streaks should not occur in places near the inner edge of the benches as well as along the central part. There is a considerable area of the benches, especially in the upper part (*See* Figure 22), that has not been mined, and it is probable that further hydraulic operations can be made to pay if the water from both Devils canyon and from the west were made available at one point.

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 (Figure 23) was made by the Cariboo Exploration Company when operations were being carried on at the Slough Creek mine, S. Medlicott being the manager. Water was brought from New creek by a ditch $1\frac{1}{2}$ miles long. One $4\frac{1}{2}$-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 (Figure 25), named after a French Canadian (a Mr. Bourassa) who, because of his great strength and fighting abilities was nicknamed "Dragon," 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 road ends at the east bank of the hydraulic pit on the creek and an aerial tramway is used for transport to the west side. Only the middle part of the creek, from a point about one-half mile above the junction with Willow river up to the dam, is shown on Figure 25. 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 bottom of which, where it leaves the present channel just above the upper end of the canyon, is about 25 feet below the level of the present creek. Above the canyon the valley widens and is deeply drift-filled, except where it has been hydraulicked out. Bedrock is exposed on the west side of the valley near the dam and at a few places in the hydraulic pit. The bedrock in the deepest part of the channel from the head of the canyon to the head of the hydraulic pit has an average gradient of nearly 7 per cent,

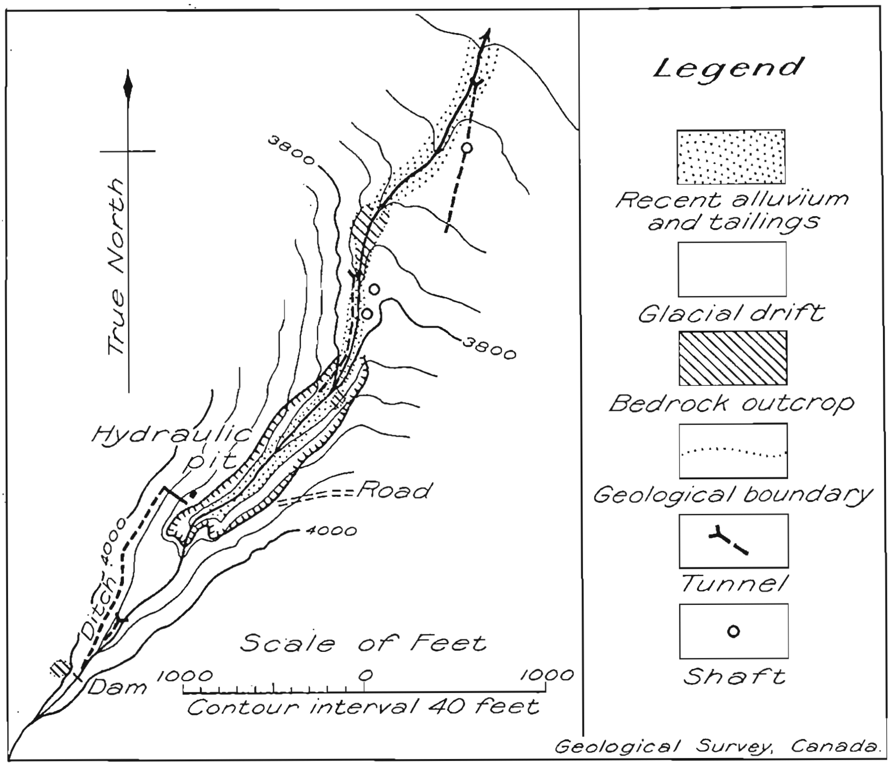

Figure 25. Dragon creek, Cariboo district.

but the grade flattens off in places to 3 or 4 per cent. In the upper part of the creek the average gradient of the bedrock is probably somewhat greater.

Prospecting and mining work on Dragon creek have been carried on almost continuously since the early days and a great deal of work has been done. One-eyed Davis, who also had a claim on Williams creek, was one of the first to mine on the creek. The creek was drifted from above the canyon to above the present head of the hydraulic pit. A tunnel was started about 400 feet below the present dam and struck bedrock not far from the dam. The workings are said to have been abandoned at the time of the Cassiar excitement in 1874. A long tunnel near the forks of the creek in the upper part was run by Otto Muller in recent years, but bedrock was not reached. In the seventies a tunnel was started near the junction of Dragon creek and Willow river and is said to have been run through very bad ground for over 1,000 feet up Dragon creek, with the object of reaching the deep lower part of the creek, but bedrock was not reached. It was early recognized that a buried channel occurs on the east side of the rock canyon and in the eighties a tunnel (shown on Figure 25), starting at the creek bank 800 feet below the foot of the canyon, was run. An air shaft 350 feet from the mouth of the tunnel is 46 feet deep. Rim-rock of the valley of Willow river was struck and was drifted along for some distance, but it proved to be steep, and the old channel was apparently not found as the tunnel was too low. A shaft was also sunk alongside the creek near the upper end of the old channel and proved that a deeper channel than the present one through the rock canyon exists. It could not be mined from the upper end, however, because of the water pressure. No further attempts to mine the old channel were made until recently except that another shaft, said to be 22 feet deep, was put down near the upper end of the channel where it joins the present work. In 1896, a Seattle company known as The Dragon Creek Hydraulic Mining Company, under the management of Gust. Lange, acquired hydraulic leases on the creek. Hydraulicking was started in 1898 and has been carried on in most seasons since that time. At the present time the property is owned by Leo Muller who holds two half-mile leases and one record claim. The hydraulic pit had been carried upstream 1,400 feet by the end of the 1923 season, the ground in the deepest part of the channel averaging 50 to 60 feet in depth. Water under a head of about 125 feet is obtained from Nelson creek by a ditch from the dam 930 feet above the head of the pit. There is an abundance of water for a week to ten days during the freshet, but during low water the flow of the creek does not exceed 100 miner's inches. Where the dam is in commission, one to three hours daily run using a No. 3 monitor can be had throughout the summer except in very dry years. The material of the bank consists mostly of boulder clay with some glacial gravels. The boulders are numerous and some are large. They are removed and piled in the pit by means of a derrick run by a small, water-driven Pelton wheel operated by a hose take-off from the pipe-line. There are forty-three sluice boxes laid on a 5-inch grade. The grade was formerly 4½ inches, but was altered to obtain a better dump, and the old driftings on the west side of the pit near its head were followed. On the west side, however, the bedrock channel is somewhat lower, so that the upper ends of the boxes are at least 3 feet above the lowest part of the bedrock. The deep channel, therefore, cannot be reached by hydraulicking for some distance above the head of the boxes unless the grade of all the boxes is lowered. During the past few years, partly because of the difficulties involved, hydraulicking has been carried on, as a rule, only during the period of high water and drifting done during the winter months, by Mr. Muller and his partners. A tunnel about 625 feet long was run in the winter of 1922-23 by Mr. Muller and the Houser brothers. It started at the level of the creek just above the canyon and, as it was run at a lower level than the old tunnel, a part of the bedrock channel which had been passed over by the old tunnel was mined. The tunnel (shown on Figure 25) cuts through bedrock for a short distance near the mouth and then crosses on gravel the deep channel and strikes the bedrock again about 400 feet from the mouth of the tunnel. There thus remains in this part of the creek a short length of the deep channel below water-level that has not been mined. The work paid at the rate of about $5 a day to the hand. In October, 1923, a new company composed of local miners was formed to mine the buried channel which lies on the east side of the rock canyon and continues a short distance upstream beneath the tunnel run in 1922-23. A tunnel[1] was run from the creek bank about 50 feet above the blind shaft on the old tunnel below the canyon and about 47 feet above the level of the old tunnel. The tunnel runs towards the old channel for 520 feet, at which point bluff rock was struck. A crosscut at an angle of 45 degrees was then run towards the creek for 115 feet, at which point a raise of 50 feet to the surface was made for an air shaft. Pay-gravels were struck near the end of the crosscut and drifting up the channel was then begun. There is a raise of 6 feet in the crosscut and 6 feet in the first 50 feet of the channel. The dirt is taken out in cars and washed at the creek. The channel was drifted three sets wide and up to October, 1924, thirty-five sets with 8-foot caps had been taken out. The ground averaged $1\frac{1}{2}$ ounces to the set or about wages. The length of the channel from where it was struck at the lower end to where it crosses beneath the creek above the canyon is about 500 feet.

The gold on Dragon creek is noted for its coarse, nuggety character and for its fineness or purity. Assay values average about $19. The gold is evidently local in origin and occurs mostly on bedrock, but some is found in the gravels for a few feet up from the bedrock. These gravels, as seen in the tunnel above the canyon, are glacial and clayey with an occasional large boulder. No evidence was seen of glacial erosion of the bottom of the valley. The valley bottom may have been protected from ice erosion because of its narrowness and by deposition of glacial drift in it, so that the gold may be pre-Glacial in origin, although the discontinuous character of the pay-streak and the fact that some of the gold is mixed with the glacial gravels seem to show that the ancient pay-streak was disturbed and eroded to some extent as the result of glaciation. The buried rock channel alongside the Recent canyon may be pre-Glacial or possibly interglacial in age. It is evidently an old channel of Dragon creek and was formed before the present channel was cut and before the deposition of the glacial drift that fills it. It is, therefore, reasonable to suppose that pay-gravels occur in the bottom of the channel. The work so far done does not indicate that the values are very great, but better values may be found higher up. The bedrock valley of Dragon creek, like that of Nelson creek, is hanging with respect to the bedrock valley of Willow river, that is, the bedrock gradient suddenly and markedly increases at the junction of the two valleys. This shows that Willow River valley was probably over-deepened by ice erosion. The valley is deeply drift-filled, and there is no reason to suppose that it contains any rich deposits.

[1]Not shown in Figure 25 as the mapping was done before the tunnel was started.

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. As already pointed out, there are difficulties in hydraulicking, especially the insufficient supply of water. 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.

New Creek

New creek flows into Slough creek from the southwest and is the first below Nelson creek. It is comparatively short with a high gradient, and in the dry season has a very small flow of water. In its middle part the stream flows in a rock canyon for about 1,500 feet. There are one or two buried channels alongside the canyon. Below the canyon the drift deposits in the valley bottom are thick. There is a great deal of glacial silt and clay and the "slummy" wet ground on most of the creek has rendered prospecting difficult.

Considerable prospecting and a small amount of mining have been done, but nothing of value has been found. A tunnel starting near the road in the lower part of the creek was run in the early days, by Wm. Brown of Jack of Clubs creek, but did not reach the channel. Brown has recently returned to the creek to continue his work. Farther up the creek a tunnel was run in the early eighties by the Glamorgan Company. When it was 600 or 700 feet a blind shaft was sunk 20 feet to bedrock. Drifting was commenced from the bottom of the shaft, but work paid only about 1 or 2 ounces to the set, about $200 in all having been recovered. Several prospect pits and shafts were also sunk. The bedrock gravels where prospected are said to be glacial and clayey. The general experience in the district has been that where these occur on bedrock the pay is not likely to be either rich or continuous. Apparently no gold was found in the bed of the creek above the canyon. Brown holds that there is a stretch of the creek for about 1,500 feet between the Glamorgan tunnel and his tunnel which has not been prospected, and that the most favourable channel is on the northeast side of the canyon.

The rock canyon is an interesting feature because of its height above Slough Creek valley and the difficulty of explaining how it was formed in post-Glacial time by such a small stream, especially as there are on both sides of it lower, drift-filled depressions. It was probably initiated by a more powerful stream coming from the upland during the closing stages of glaciation and at a time when the valley of Slough creek was still occupied by ice. Once the rock cutting was started the creek would persist in the canyon that was formed.

Montgomery Creek

Montgomery creek is the next creek below New creek and flows into Willow river. The creek has a steep gradient and bedrock is not exposed except in the upper part and in a few places along the sides. A tunnel starting near the road, was run in the seventies and several prospect pits and shafts were sunk along the creek, but apparently little gold was found.

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 (Figure 26) down to Stanley, 7 miles from its source, is narrow and steep-sided. Its sides rise steeply to heights of 200 to 300 feet, and above that height slope more gradually to the summit levels 1 to 1½ miles away from the stream and about 1,500 feet above its bed. In the narrow part of the valley above Stanley there are two rock canyons, one at the mouth of Houseman (Eagle) creek and the other, known as Spruce canyon, 1½ miles above Stanley. There is a buried channel of the creek on the north side opposite Spruce canyon and another beneath the point opposite the lower part of Van Winkle creek. They were mined out by drifting, mostly in the early days. Bedrock is exposed in the part of the creek above Stanley, at the canyons, and in places on the sides of the valley, but is largely concealed by glacial deposits which partly fill the valley. The depth to bedrock in the part above Spruce canyon was 30 to 50 feet and the deep channel was found by the miners to be 20 to 50 feet wide. The ground from the canyon to Stanley was 60 to 100 feet deep and the deep channel 50 to 140 feet wide. 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. The old workings showed that the buried channel has a fairly even grade, gradually decreasing downstream, and that there are no very marked sharp rises or any deep depressions in the bedrock. 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 Wingdam 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.

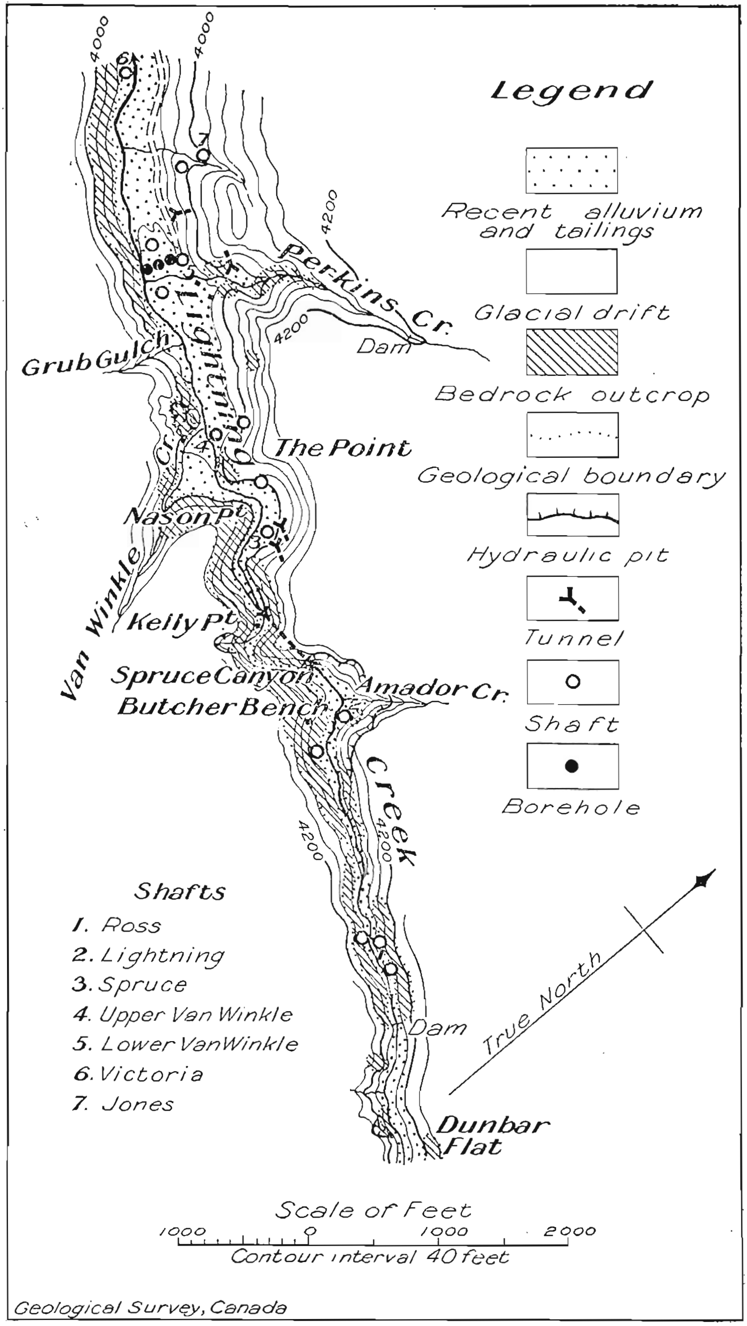

Figure 26. Part of Upper Lightning creek, Cariboo district.

Boulder clay largely occupies the sides of the valley above Stanley, but very little is said to have been met in shafts in the deep channel above the mouth of Van Winkle creek. Nearly all the deposits are gravels, except where boulder clay partly fills the buried channels alongside the newer channels. There is said to be some boulder clay in the valley bottom near Stanley and the drilling records at La Fontaine mine 1½ miles below Stanley and 2 miles farther down (Figure 29), show pretty clearly that boulder clay forms a part of the valley filling at these places. The morainic deposits, the surface of which is characterized by undrained basins and irregularly shaped knolls, are partly sands and gravels and partly boulder clay. They extend nearly across the valley opposite the lower part of Davis creek and probably form an impervious stratum above the bedrock gravels. It is a debatable point how much of the gold-bearing gravel that was mined in the deep channel was pre-Glacial or whether any of the gravels are pre-Glacial. The gravels seen on several of the dumps of the old mines above Stanley are partly the typical "flat wash" and show no evidence of glacial action. The gravels, especially those in the bottom of the deep buried channels alongside the newer rock canyons, are probably in part at least pre-Glacial. The gravels in the bottom of the deep channel below Stanley, judging by those seen on the dump at La Fontaine mine, appear to be glacial gravels. Unlike Williams and Slough creeks, Lightning creek in the section above and below Stanley for some distance does not appear to contain any interglacial pay-streak. It may be that the drift filling the channel was partly eroded out and the channel deepened somewhat by stream erosion during a temporary retreat of the ice. The wide part of the valley below Stanley may have been deepened by ice erosion, although probably not to any great extent, for some of the bedrock valleys of the tributary streams are graded to the bottom of the main channel. The narrow bedrock channel of the creek above the mouth of Van Winkle creek could hardly have been eroded by the ice, because of the narrowness of the channel and because the tributary stream channels are graded to the bottom of it. It must have been formed by stream erosion before it received the glacial drift. Spruce canyon is clearly post-Glacial in age and, unlike the somewhat similar Black Jack canyon on Williams creek, it contained considerable gold, the reason being that the canyon was cut partly through rock benches on the south side, which carried concentrations of placer gold. The rich part of the creek extended from the Vulcan ground just above Stanley to the Lightning claim above the head of Spruce canyon. The deep channel of the creek above the Lightning claim is said to have been unprofitable, although there were rich spots in places as far up as the foot of Eagle canyon. Considerable gold was found on Dunbar flat, a series of drift-covered rock benches on the north side three-quarters of a mile above Spruce canyon, on the famous Butcher bench on the south side near the head of the canyon, and on Nason point just above the mouth of Van Winkle creek. The Butcher bench is a gently sloping rock bench 60 to 80 feet above the stream, and is a remarkable feature, for it appears to be a remnant of an old stream channel of the creek when it flowed at a much higher level than at present, and has been preserved in spite of downcutting of the stream valley of over 100 feet and in spite of glacial erosion. The bench is said to have produced $122,000 in gold from an area of only a few square yards. The Dunbar flat is apparently an upstream continuation of the bench, the part between having been eroded away and the old pay-streak largely destroyed by the effects of glaciation.

A curious fact, and one that has often been commented on by the local miners, is that the tributaries of Lightning creek on the south side were rich in gold, whereas those on the north side contained little or no gold. It has also frequently been noted that in the district as a whole the streams flowing north, northeast, and northwest contain much more gold than those flowing in the opposite directions. There are, of course, exceptions. Keithley creek, a rich gold-bearing stream, flows southeast and there are streams that flow north in the gold belt, yet carry little or no gold. The placer gold on the creeks was derived by weathering and erosion of the vein gold deposits in the bedrock and where these are abundant the creeks in the vicinity are or were rich in gold, so that it may be largely accidental that the northward flowing streams are the richest. Nevertheless the rule holds good in so many cases that there is probably some good reason why this is so. One theory has been suggested to the writer by Harry Jones, who has lived on Lightning creek since 1863, except for a few years absence, and is one of the ablest of the mining men in the district. He suggests that the gold was partly derived from the gold-bearing veins in the bedrock by erosion by glaciers; that the valley glaciers were much better developed on the northerly than on the southerly slopes—being less exposed to the sun—and, therefore, accomplished more erosion; and that the gold was concentrated in the northward-trending valleys and was later buried by slides from the valley sides and by lake deposits in the slide-dammed valleys. There are certain objections, however, to this theory, which has been pretty widely accepted by the prospectors. The conception of huge rock and mud slides from the mountain sides is one that has persisted since the early days. There are numerous slides in the district, especially on some of the steep-sided creeks, such as lower Lightning creek, but they are not nearly so common as is generally supposed, and the valley filling in many places consists of morainic materials, as below Stanley, deposited at the end of a glacier in the valley bottom and of boulder clay deposited beneath the ice or from the ice when it melted. The stratified glacial silt (slum) was deposited in water bodies which may have been dammed by ice tongues or moraines in the valley bottom and possibly in places (as Jones suggests) by slides, and the glacial gravels forming a considerable part of the valley filling were deposited from streams flowing from the ice. There is no evidence that the moraines and extensive sheets of boulder clay in some of the valley bottoms were formed from slides. The gold in the bottom of the channel must have been deposited before the valley was filled with the glacial drift, except perhaps such parts as may have been deposited along with the glacial gravels, and where these extend down to bedrock, may have become concentrated by working down through the gravels. It is true that the northward-flowing valley glaciers were the most active ones, but near the heads of the creeks, for example in the upper parts of Williams, Antler, and Jack of Clubs, where erosion by valley glaciers was much greater than lower down on the streams, there is no gold. Evidence of this greater erosion is supplied by the cirques and broad, flat-bottomed valleys. Glacial erosion of the bedrock has not been very extensive, for the glacial drift averages less than 100 feet in thickness over the whole area, and it is evident from the topography that the main stream valleys existed before the Glacial period. It is fairly certain that concentrations of gold derived from the wearing away of great thicknesses of bedrock occurred in these old valleys and that the gold in the present valleys was partly derived by erosion of the old pay-streaks and concentration into new pay-streaks, and that in places the old pay-streaks remained intact in the valley bottoms in spite of glacial erosion and deposition. Another theory, which seeks to account for greater richness of the northward-flowing streams, was suggested to the present writer by William Brown of Jack of Clubs creek and appears to have considerable merit. The theory is that because the rocks of the area dip, as a rule, northeast and north, their edges do not form good riffles for catching and holding the gold on the south and southward-flowing creeks, and, therefore, the gold tends to work down the creeks, and that because of the structural features of the bedrock, the streams in cutting down their valleys have tended to shift towards the north and northeast. On Lightning creek the gold-bearing rock benches are all on the south side except at one or two places in the upper part of the creek. This shows that the stream has shifted to the north and that the tributary streams on the south side have been enriched by cutting through the benches.

The location of the old claims on Lightning creek down as far as Jawbone creek, and the depths of many of the shafts are shown on Bowman's map of Lightning creek[1] and in part on a map published in the Annual Report of the Minister of Mines, B.C., 1876. Some of the more famous of the claims, which, however, were not the original 100-foot claims but Company claims, were the Lightning in the bed of the creek just above the Spruce canyon, the south Wales and the Spruce, covering the buried channel opposite the canyon, the Point claim covering the buried channel under the hill opposite the lower part of Van Winkle creek, and lower down the Van Winkle, Victoria, Vancouver, and Vulcan, the latter covering the ground just above Stanley, and part of lower Chisholm creek.

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. George Murdock, who came to Cariboo in 1864, holds two hydraulic claims, one on the south side of the creek nearly opposite the lower end of Dunbar flat and the other high up on the hill-side in the forks between Houseman creek and Lightning, but has only a small supply of water for working the lower claim on the old Perseverance ground where there is a high bank of boulder clay and gravels overlying bedrock benches. It is several years since the upper claim was worked, but it is said to have some merit. Its altitude, however, makes it difficult to obtain an adequate supply of water. Most of the water on upper Lightning Creek has been held by the Lightning Creek Hydraulic Mining Company. Ground-sluicing at the upper end of Spruce canyon has been carried on by Harry Eden, and one-quarter mile farther upstream, by

[1]Geol. Surv., Canada, Ann. Rept., vol. III, Map 365 (1895).

George Shaw. The deep channel of the creek has long been considered as mined out and a great deal of work has been done on the benches with no very favourable results. Considerable information regarding the history of mining on the creek is given by Bancroft[1] in the Annual Reports of the Minister of Mines, British Columbia, and by G. M. Dawson,[2] who examined the creek at a time when mining was being actively carried on. The following brief account of mining on upper Lightning creek is based mainly on the above-mentioned reports, and on information obtained from Harry Jones, George Murdock, J. F. Tregillus, J. F. Williams, and other mining men in the district.

Gold was discovered on Lightning creek in July, 1861—the same year in which Williams creek was discovered—by Ned Campbell and his companions, who opened a rich claim in the lower part of Spruce canyon, from which they took out 1,700 ounces in three days' washing. The discovery was on what was later the Spruce Company's ground, covering Ned Campbell's claim and the Whitehall claim adjoining, which together yielded $200,000. The opening of Campbell's claim cost $25,000, but it yielded $100,000 in three months. A great rush followed this discovery, particularly to Van Winkle creek, where 2,000 feet at the lower end yielded from $100 to $250 a day to the man, through the season. Up the creek the lead disappeared. The diggings on Last Chance creek, another tributary on the south side just below Stanley, were likewise opened in 1861. The Discovery Company, consisting of four men, took out 40 pounds of gold in one day, and the yield that season, from half a mile of the creek, was at least $250,000. Chisholm (Oregon), Davis, and Anderson tributaries also yielded quite a quantity of gold from their shallow parts. The second season's work on Lightning creek yielded comparatively little, for the gravel being loose and porous was difficult to work, though the pay-streak was only from 8 to 30 feet below the surface. From Houseman creek to the Water Lily claim at the mouth of Davis creek, every foot of ground was occupied and shafts were sunk in many places; but they all (below the old town of Van Winkle opposite the mouth of Van Winkle creek) proved unsuccessful, owing to the inefficiency of the draining machinery. After two more seasons of disastrous trial, they were all abandoned in the autumn of 1864, from the upper end of the Ross claim, downstream. The discovery of gold on the famous Butcher bench was not made until one or two years after the original discovery. Mr. Murdock states that the discovery was made by Joe Gilmour on November 4, 1863, and that the claim was so-named because the actual discovery of gold was made with a butcher knife. It is said to have produced the largest nugget from Cariboo—$36\frac{1}{16}$ ounces.

In 1870 the Spruce, then called the Davis, as well as the Ross, Lightning, Van Winkle, Victoria, and Vancouver Companies, resumed work by sinking shafts into the deep channel, and with the aid of improved machinery and methods the water was controlled. The last three companies, situated below the old town of Van Winkle, effected their object by sinking in the bedrock at the side of the creek, and thence drifting into the channel. At the same time a costly bedrock drain 1,700 feet long was run

[1]Bancroft, H. H.: "History of British Columbia."
[2]Geol. Surv., Canada, Rept. of Prog. 1876-77, pp. 108-111.

by the Van Winkle company. It joined the main work shaft (200 feet above the lower line of the claim) at 60 feet below the platform and 20 feet from the bottom, and was later continued upstream to, or nearly to, the deep ground. As a result of these successful engineering feats, fresh localities were opened for a distance of 5 miles along the creek and gold began to flow again. In nine months the Van Winkle, Victoria, and Vancouver mines alone yielded about $500,000, of which $218,262 came from the Van Winkle. In 1875, the total production from Lightning creek was $513,527, and that of the rest of Cariboo district, including tributaries of Lightning creek, was $252,731. The Costello claim, just below the town of Stanley, was the lowest producing claim (farthest downstream) in the deep channel of the creek, although the tributaries Davis and Anderson below Stanley were found to be gold-bearing and were worked in the shallow ground. Jawbone, Amador, and Houseman creeks remained undeveloped, although strenuous efforts were made to reach the bottom of the latter. The Gladstone and Eleven of England Companies, below the town of Stanley, put up heavy and costly machinery, but met with little success in their mining efforts. In 1876, the Eleven of England Company struck pay in the deep channel. Mining was carried on for several seasons, but only about $20,000 in gold is said to have been recovered. The Costello Company expended $37,493 before finding gold. The cost of extracting the gold up to November 1, 1875, was $33,852 and the gold extracted up to that date[1] was worth only $20,476.

In 1876 and 1877 mining by the company is said to have about paid expenses and when the last work was done beneath the graveyard below Stanley the ground paid about 3 ounces to the set. The Vulcan Company, consisting of ten full shares, is said by George Murdock to have paid $10,000 dividends to the share, the Vancouver, with thirteen interests, $21,000 to the share, the Victoria, with sixteen interests, $80,000 to the share, and the Point, with six interests, $13,000 to the share. The Van Winkle is said to have paid still higher dividends. As there was very little clay in the bed of Lightning creek above Stanley, considerable difficulty was experienced in draining the ground and keeping the mines clear of water during the season. The difficulty was overcome by extensive pumping being done simultaneously by several companies. G. M. Dawson, who examined the creek in 1876, stated,[2] "The whole of the deep workings are filled with water at the time of the spring floods, and it is sometimes late in the summer or autumn before the pumps again acquire the mastery. In October of 1876 the following companies on Lightning creek were driving their pumps day and night, the Van Winkle being the only mine clear of water. Costello claim—pump, 12-inch diameter, 9-foot stroke, making 10 strokes a minute; Vulcan claim—pump, 12-inches diameter, 6-foot stroke, making 18 strokes a minute; Vancouver claim—pump, 12 inches diameter, 9-foot stroke, making 10 strokes a minute (double acting); Van Winkle claim—pump, 10 inches diameter, 14-foot stroke, making 10 strokes a minute (two pumps). The quantity of water being raised at this time, would, therefore, amount to about 13,870 gallons a minute, or 19,972,000 a day." In the upper part of the creek paying deposits were

[1] Evans, John, Ann. Rept., Minister of Mines, B.C., 1875, p. 10.
[2] Geol. Surv., Canada, Rept. of Prog., 1876-77, p. 111.

found on the Dutch and Siegal claims (later the Perseverance) and on the Ayrshire Lass claim in the bed of the creek below Eagle canyon. Two long tunnels were run, one parallel to Eagle canyon on the south side and the other on the Great Eastern claim southeast of the Ayrshire Lass claim, but no pay was found. Hydraulicking of the bench deposits at Dunbar flat was carried on by two companies in the eighties and about 1911 to 1913 a great deal of work was done, by Wm. Ogden, on benches 200 to 300 feet higher than the Dunbar benches, but only a little gold was found. On Amador creek a long tunnel was run in a buried channel parallel to the rock canyon on the creek a few hundred feet above the mouth, and a shaft was sunk above the canyon, but apparently little gold was found except in the surface deposits in the upper part, as on Chisholm creek, although the creek has a wide and deep valley. Hydraulicking was done about 1900 by the Van Winkle Hydraulic Company on the point on the southwest side of Van Winkle creek, and a great deal of work was done by George Murdock and others in cleaning off the rock slopes of the creek on the south side above the Butcher bench, under the supposition that the gold on the Butcher bench was derived from higher up on the hill slope, but very little gold was recovered.

Although the deep channel of the creek was generally considered in the seventies as mined out, important discoveries were made in the nineties on the South Wales, Spruce, and Point claims, on benches a few feet above the deep channel. Mining on the South Wales leasehold, comprising the old Spruce, South Wales, Lightning, and Ross claims, was carried on from 1895 to 1897, by Messrs. H. Jones, F. J. Tregillus, and Price, on a bench about 10 feet higher than the old worked channel and drifts were carried through the buried channel opposite Spruce canyon upstream practically to the old Lightning shaft. In 1902 somewhat similar discoveries were made by Sam Montgomery, Jones, Tregillus, and others on the Van Winkle and adjoining Point claims lower down. A shaft was sunk in 1901 from a level of 4 or 5 feet above the present creek on the right side at the base of the steep hill along which the old abandoned road to Richfield is cut. The shaft was sunk 41 feet in gravel to a pay-streak about 15 feet higher than the deep-worked channel, and overlying a stratum of slum. The pay-streak, which contained many large boulders, paid irregularly for about 20 feet to where the bedrock was struck on what afterwards proved to be a bench. The bench for a number of sets (8-foot cap) paid from 6 to 9 ounces, and gradually improved until one set yielded 50¼ ounces and another 70½ ounces, but these were considerably above the average. The gold was very coarse, ranging from ½ to 6 ounce pieces. Opinions differed as to the source of this lead, whether it came through the South Wales deep ground or through the canyon. It was evidently, in part at least, Glacial in age, for the pay-gravels were underlain by glacial silt. About $24,000 in gold was recovered. The New Point Company (Kelly and Fry) mined the adjoining ground, and farther into the hill took out about $55,000 in 1902 and 1903. The ground in the bed of the creek above the head of Spruce canyon was mined from 1913 to 1918, and for a short time in 1920, by the Lightning Creek Hydraulic Mining Company under the management of L. A. Bonner. An extensive system of ditches from the upper part of Lightning creek was constructed and a bedrock tunnel

400 feet long, through which the tailings were sluiced, was driven upstream from the lower part of Spruce canyon. Two hydraulic elevators were used and the deep channel was cleaned out for a distance of nearly 600 feet upstream from the head of the canyon. Comparatively little gold is said to have been recovered for, apparently, nearly all the gold was concentrated on bedrock because of the open porous character of the

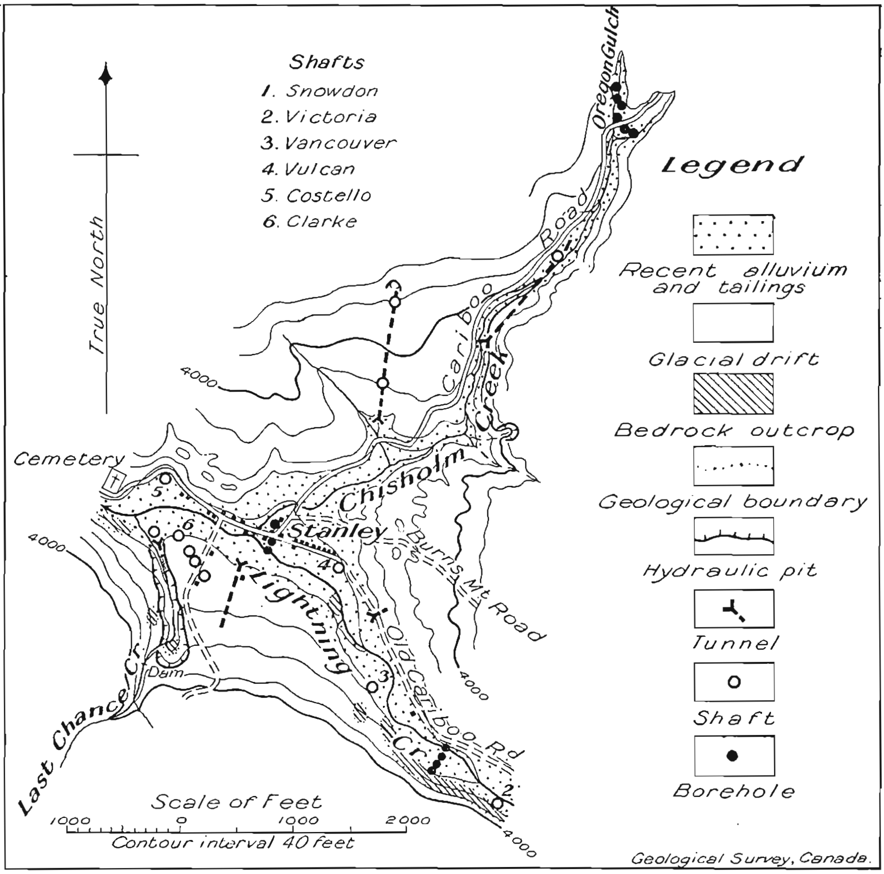

Figure 27. Chisholm creek, Cariboo district.

gravels, and the bedrock had been very thoroughly cleaned in the previous drifting. A small piece of unworked ground was struck near the upper end of the Lightning claim, but the rock sides of the channel proved to be nearly vertical, so that there were no bench deposits of value such as had been expected. In 1915 three cross-sections of borings (Figures 26 and 27) were made by the Yukon Gold Company to test the ground below the canyon for dredging. In all, fifteen borings were made and the average value for all the holes is said to have been only 7 cents a cubic yard, and the

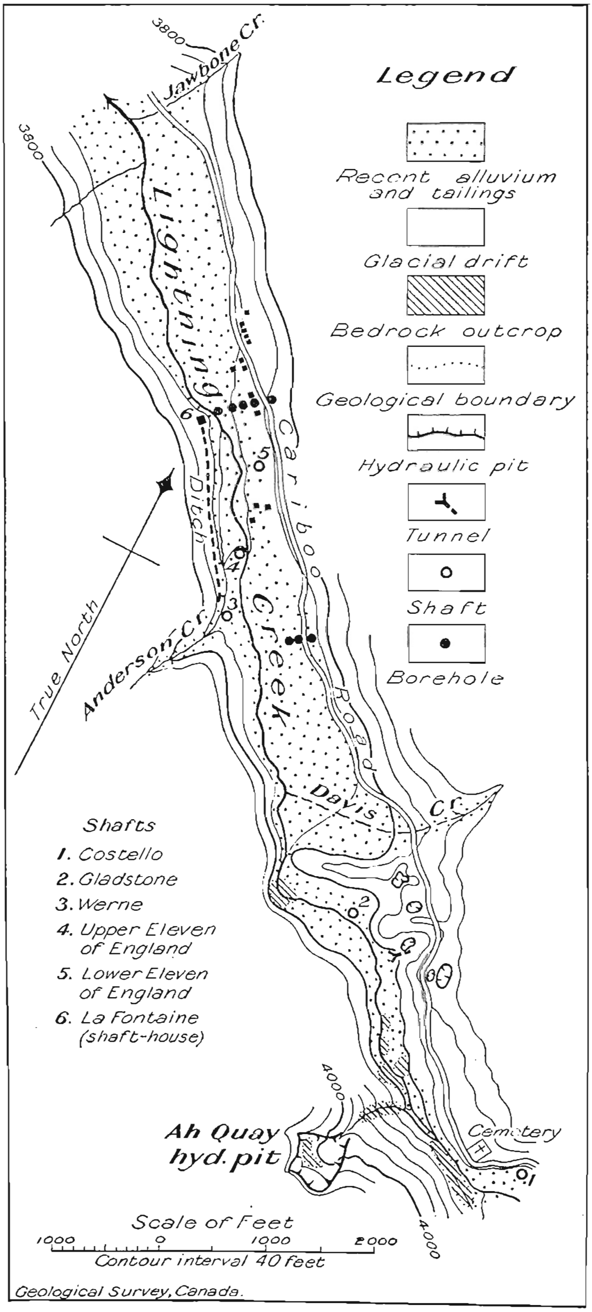

Figure 28. La Fontaine mine, Lightning creek, Cariboo district.

highest value for any one hole 32·2 cents. The maximum depth at the upper line was 72 feet, at the middle line 76 feet, and at the line of three holes at Stanley 88 feet. Apparently, in the part of the creek drilled, as in the upper part, nearly all the gold was on bedrock, and nearly all had been extracted.

La Fontaine mine (Figures 28 and 29), 1½ miles below Stanley, was operated from June, 1905, to March, 1907, by Cariboo Consolidated, Limited, under the management of M. Bailey, and was probably the best equipped and most efficiently operated deep-drifting mine that has been opened in Cariboo. The mine management, however, may be open to criticism because of the very expensive character of the development work and because the ground was not thoroughly tested before mining. The presence of rich pay-gravels may have been assumed because of the results obtained on the old Eleven of England claim, but that assumption proved very misleading, for the deep channel gravels proved not sufficiently rich to pay for drifting. The property included a number of claims extending along Lightning creek, from the mouth of Last Chance creek just below Stanley for about 5 miles downstream, and the old Eleven of England claim, on which considerable drift mining had already been done. Development work at La Fontaine began in April, 1903. A cross-section of bore-holes to determine the depth of the channel was first put down near the lower line of the Eleven of England claim. The cross-section and another line of borings, also put down by the company, 2 miles lower down on Lightning creek, are shown on Figure 29. The sections are as interpreted by the present writer from the drilling records, for copies of which the writer is indebted to L. A. Bonner, local manager for Cariboo Mining Syndicate of London, England, the present owners of the property. A working shaft was sunk 165 feet in bedrock on the south bank of the stream and a main tunnel was driven 305 feet to the channel. A drive from the tunnel was made downstream for 178 feet and a crosscut run. A main east tunnel, run upstream in bedrock from a point 215 feet from the shaft, was eventually extended to the Eleven of England upper shaft, a distance of nearly 1,350 feet, and was connected with the shaft by an upraise. Upraises were made at intervals from the main east tunnel; from the upraises crosscuts of the channel were made and drives upstream. The object in driving the long tunnel upstream in bedrock was to render it possible to break into the channel at several places, so as to drain the ground by crosscuts ahead of the blocks in which breasting of the gravels was being done, and to avoid the risk of breaking into the old flooded workings. Both the old workings upstream from the Eleven of England lower shaft and those above the upper shaft were eventually drained, but it was found necessary to fill in the upper shaft, as it enabled water from the surface to enter the workings. The main shaft was equipped with two 18-inch Cornish pumps operated by a Corliss pumping engine using 4 cords of wood a day. There were also a compressor, a hoisting engine, and a generator and exhaust fan engine, the total amount of fuel used being 6½ to 10 cords a day, costing about $3.50 a cord. Pumping to drain the ground began in January, 1904, when the main tunnel was extended to the channel; in June, 1905, the ground was sufficiently drained to permit of breasting operations, and active mining began. A maximum of about 2,000,000 gallons of water a day was pumped,

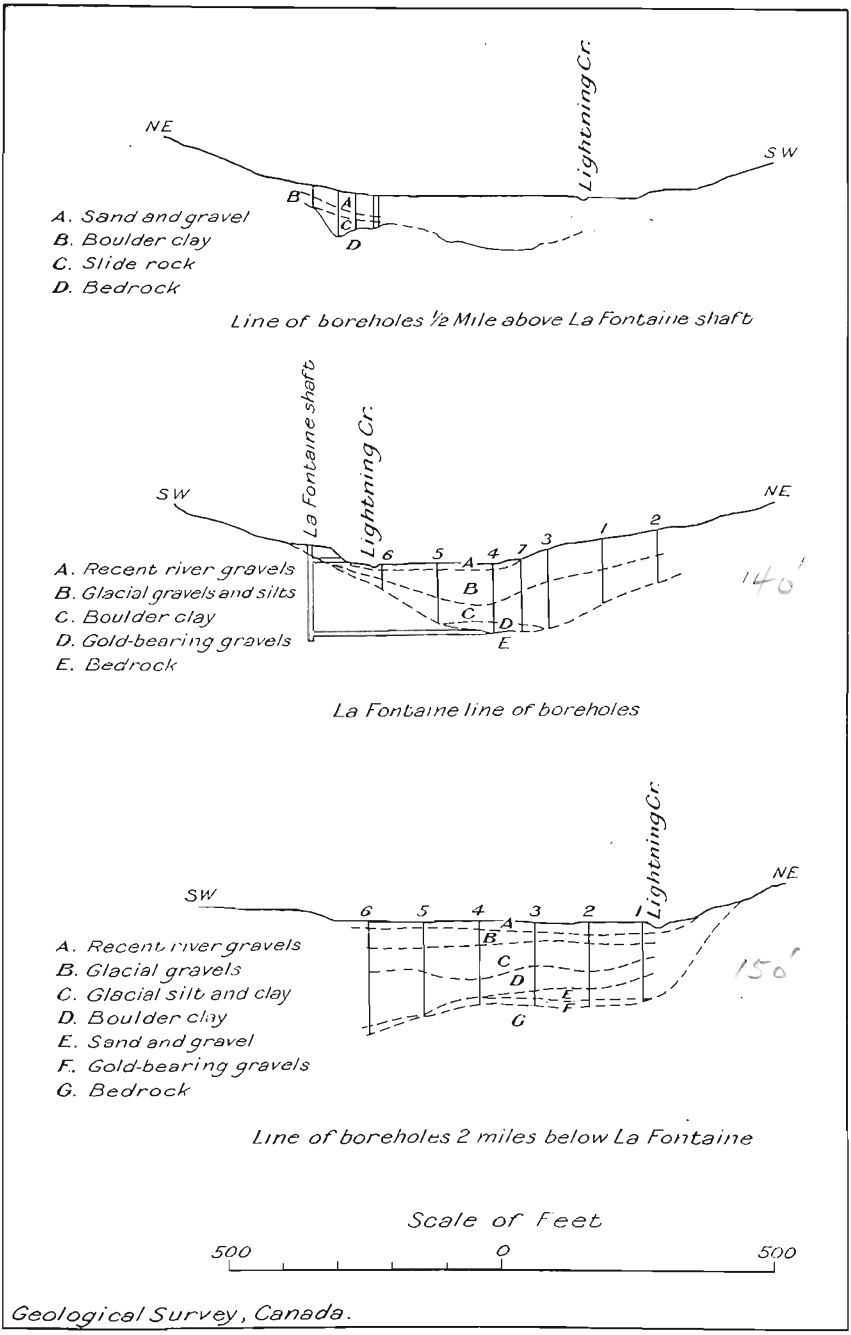

Figure 29. Cross-sections of Lightning creek near Stanley, Cariboo district.

but the average was much less, and after the old driftings were unwatered the average flow was only about 560 gallons a minute or 806,400 gallons a day. The amount pumped increased only slightly during the freshet, so that it is probable the underground water is separated from the surface water by an impervious stratum extending for a considerable distance up the creek. The ground was drained for a short distance above the Eleven of England upper shaft, but not up to Stanley. Drift mining was done at many places along the channel, which was found to be over 150 feet wide in places and to have an even and low gradient. The last work done was somewhat above the mouth of Anderson creek and above the old driftings from the Eleven of England upper shaft. The total amount of gold recovered during the mining operations, which extended over nineteen months, was 2,035 ounces having an approximate value of $37,450.[1] The average value per cubic yard was $3.11. In addition, 53 ounces were recovered during the development work. The total underground cost of the breasting, cleaning bedrock, timbering, tramming to the shaft, etc., averaged $1.65 per cubic yard of gravel mined, which is probably about the lowest underground cost for drift mining in the district. But this cost did not include the cost of pumping or the fixed charges. The development work cost about $150,000 and the operating costs of the mine, not including fixed charges, were possibly $4,500 a month. Before work was suspended at the mine in April, 1907, it was reported that ground of much higher value than the average of that mined had been found at the mouth of Anderson creek. In any case this ground is only of small extent, and apparently sufficient work was done in the main channel of Lightning creek above the mouth of Anderson creek to prove that the gold values were not sufficiently high to pay for drifting. One of the last pieces of work was a crosscut (prospect drive) to the north side of the main channel, about 700 feet above the old Eleven of England shaft. In this crosscut the main channel was about 120 feet wide and there was another channel about 30 feet on the north side and about 10 feet above the main channel. Water from the end of the drive and the fact that the main channel contained little gold led L. A. Bonner to believe that there was another side-hill channel on the north side. Five borings (Figures 28 and 29), made in 1921 and 1922, showed that there is a depression in the bedrock, but apparently no well-defined stream channel was found, nor was any gold obtained from the bore-holes. The cross-section of bore-holes 2 miles below La Fontaine mine showed that the ground has a maximum depth of at least 200 feet. The boring was done with an hydraulic jetting machine and, although the method was not entirely satisfactory for determining the gold values, it probably gave a fair estimate. Mr. Joseph Wendle, who was in charge of the drilling, states that probably not more than 10 cents in gold was recovered from any of the holes.

The Ah Quay hydraulic mine is located fairly high up on the south bank of Lightning creek, about one-half mile below Last Chance creek. The property was worked for many years, but has not been operated for some time past, except on a small scale by J. F. Williams, the present owner. It was owned and operated from 1898 to 1903 by Cariboo Consolidated, Limited, and was later rented and operated for several years by

[1]Ann. Rept., Minister of Mines, B.C., 1906, p. 39.

individuals. Water for hydraulicking was brought by a ditch from Last Chance creek. A tunnel was run through bedrock for 580 feet and drifts, upraises from the tunnel, and shafts totalling about 200 feet were run and sunk to determine the depth and values of the gravels. The recent work by J. F. Williams has been done near the lower end of the pit where Mr. Williams holds there is a buried rock channel.

The Last Chance hydraulic mine at the mouth of Last Chance creek (Figure 28) is owned by Kwong Lung Kee and 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. A long cut was extended upstream from Lightning Creek flat and the bedrock in the pit was reached only in 1922. A long drain tunnel parallel to the pit had been run in the early days and considerable drifting had been done from the old Clarke shaft near the mouth of the drain tunnel. 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. There are several shafts, in addition to the Clarke shaft, near the lower end of the hydraulic cut and on the benches on the south side of Lightning creek opposite Stanley. The most recent one near the mouth of the old drain tunnel was sunk by J. F. Williams who maintains that part of the old channel of Last Chance creek was not mined out, and that the shaft did not reach the channel. Many years ago a tunnel 400 or 500 feet long was run on the south side of Lightning creek opposite Williams store at Stanley. The tunnel is said to have followed the bedrock on the benches all the way, except that in a few places there were depressions in the bedrock below the tunnel level, but apparently very little gold was found. The rock benches extend upstream to the Victoria ground and in the upper part where the ground is shallow were mined to some extent by open-cut work.

The total production of gold from Lightning creek and its tributaries is not definitely known. It was estimated[1] 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

[1]Ann. Rept., Minister of Mines, B.C., 1875.

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 for 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.

Chisholm Creek

Chisholm creek (Figure 27) flows south into Lightning creek at Stanley and occupies a broad, deeply drift-filled valley, especially in its lower part below the junction with Oregon creek. Considerable mining was done in the early days on Oregon creek, where the ground is fairly shallow, and attempts were made to mine the deep channel of Chisholm creek. Drifts were run from the Snowdon shaft, said to have been 203 feet deep, and to have been sunk by David Edwards. A drain tunnel about 900 feet long was run to the shaft and drifts from the 100-foot level are said to have been carried upstream for 1,200 feet. The shaft was equipped with a water-wheel and pumps. It is a matter of dispute how much of the deep channel was mined, but it is generally held that the mining did not pay. It seems probable that the lower part of the channel near Stanley was mined from the Vulcan shaft, but there may be a considerable stretch between the lower drifts and the Snowdon shaft that was neither mined nor prospected. There is no reason however, to suppose that it would prove to be richer than the parts worked. Considerable prospecting and mining development work were done on the creek from 1914 to 1917, by the Cariboo Chisholm Creek Mining Company under the management of J. A. McPherson. First, two bore-holes were put down on the west side of the valley considerably above the present creek. The upper of these holes was reported to be deeper to bedrock than the lower and, therefore, it was concluded that a side-hill rock channel existed. A tunnel 1,055 feet long, about half being through boulder clay and the remainder through bedrock, was then run to intercept the channel or depression in the bedrock, but proved to be too low. Accordingly an inclined upraise of 40 feet was made and a drift of 60 feet was run to the west to the channel, which was later crosscut after the ground was partly drained. It is stated that the gold found did not pay for drifting. A shaft was sunk about 74 feet near the end of the tunnel, but not to bedrock, and there is an air shaft for the tunnel about 600 feet from the mouth. A number of borings were made near the junction of Oregon creek with Chisholm creek, but not to bedrock, and were for the purpose of determining the gold values in the surface gravels, and the thickness of the gravel. Hydraulicking of the surface gravels of the creek was carried on for two seasons during search for a buried channel, but the work is said not to have paid. It is difficult to understand why these borings did not definitely determine whether a side-hill rock channel or bench existed and whether, if it existed, it carried sufficient gold to pay for drifting. A marked feature of the valley is its thick content of glacial deposits, largely boulder clay. This thick mass of clay which, in places, extends down to bedrock, is not conducive to the occurrence of gold, especially if the clay extended to, or nearly to, bedrock in the deep channel. It appears to extend to bedrock only in places, for bedrock gravels, judging by the old mine dump, were mined at the Snowdon and they are reported to occur in the McPherson channel. The large amount of boulder clay deposited by the ice in Chisholm Creek valley, and the very small amount in the channel of Lightning creek above Stanley, may be explained by the fact that Chisholm Creek valley is wide and deep, whereas the stream is very short and small. Consequently during the disappearance of the ice there was little opportunity for the deposition of stream (fluvioglacial) gravels in the valley, but in Lightning Creek valley, which carried a large volume of water from the melting ice, gravels would be deposited rather than boulder clay. Boulder clay in the valley also precludes the probability of underlying pre-Glacial gravels, for they could hardly have escaped erosion by the ice in such a broad and deep valley.

Considerable prospecting work was done, by the Cariboo Chisholm Creek Company and by J. F. Williams, high up on the east side of Chisholm creek, and in a pass leading to the head of Perkins gulch, and running parallel to Lightning creek. A number of shafts were sunk, several tunnels run, and ground-sluicing carried on in the upper part of Dry gulch. Mr. Williams states that some coarse, well-worn gold was found, but no definite pay-streaks.

Perkins Creek

Perkins creek, the lower part of which is shown on Figure 26, is a small stream flowing into Lightning creek from the southwest slope of Burns mountain. Coarse, nuggety gold is reported to have been found, in the early days, in shallow ground in the upper part of the creek and considerable drifting was done in the lower part of the creek. At the mouth the rock channel is narrow, but just above the mouth it widens and on both sides there are rock benches or old channels of the creek which were mined by drifting and later to some extent by hydraulicking. High drift hills line both sides of the creek near the mouth and the old driftings inside the mouth extend beneath the hills parallel to Lightning creek. Hydraulicking has been done on the creek for a number of years by Messrs. Sparks and Felker who have operated two plants, one about one-half mile up the creek, using water from its extreme upper part, and the other near the mouth, using the creek water and water brought from Amador creek by a ditch. During the past few years only the upper mine has been worked and the operations, owing to insufficient water, have been limited to a few weeks. The results have not been so profitable as formerly, because the part of the rock channel, or bench, mined during the past few years has in places a considerable filling of boulder clay, which renders hydraulicking difficult. Hydraulicking was carried on near the mouth in 1920 and 1921, but was not very successful because of the high banks on both sides and the difficulty of reaching bedrock, and obtaining sufficient grade for the sluice boxes. There is evidence that a rock channel, beginning at a point on Perkins creek 300 feet above Lightning Creek flat, extends west beneath a high drift hill. The possible occurrence of an old channel parallel to Lightning creek at this locality was long ago recognized by the miners and a great deal of work has been done in search of its continuation. The conditions at this locality are unusual and well illustrate the difficulty of tracing the old rock channels that are in many places buried beneath thick drift deposits, the surface contours of which give little or no indication of the bedrock contours. A tunnel was run west in the channel or depression in the bedrock and the bedrock was found to dip towards the west. Later, a tunnel 50 feet long, which had the rim-rock on the south side and the posts of the old Chinese tunnel on the north side, was run by Sparks and Felker. They obtained some fine gold, including a few pieces up to $1.50 in value, and found that there was a grade downstream which prevented drainage of the ground. A number of prospect pits and a tunnel driven from the bank of Lightning creek seemed to show that bedrock occurs near the surface along the north bank of Lightning creek down to the next small creek, known as the Goat Ranch, 1,000 feet below, on which two shafts were sunk in search of the channel. The lower one of these was sunk in the early days and appears to have been partly in bedrock. The other was sunk by Harry Jones and is 60 feet deep to bedrock. From the mouth of the Sparks and Felker tunnel to the bottom of the Jones shaft is a fall of 65 feet, the distance between the two points being 875 feet. Assuming that the tunnel and the Jones shaft are in the same rock channel, the average grade between the two points would be over 7 per cent, which seems rather high, so that it is doubtful whether the Jones shaft is located over the channel or where the channel joins Lightning creek. Apparently, little gold was found in the Jones shaft or in the older one nearby, as little drifting was done. The fact that the bedrock channel of Perkins creek in its lower part is not graded to the bottom of Lightning Creek channel, whereas the channels of Amador and Chisholm creeks are so graded, favours the view that a channel other than that of the present creek at its mouth exists and, where it joins Lightning creek, is graded to the bottom of the deep channel.

Fountain Creek

Fountain creek or Fontaine creek, as it is said to have been formerly known, flows southwest into Swift river, and in its upper part becomes two streams, one heading in a flat-bottomed pass near the head of Peters creek, the other heading in the northwest slope of Van Winkle mountain. The valley of the creek is comparatively narrow and steep-sided down to the "Little canyon" $4\frac{1}{2}$ miles below the forks. The "Big canyon" begins about one-quarter of a mile above Little canyon and extends upstream for about a mile. The stream flows over bedrock in both canyons, but the canyons are only a few feet deep and the valley bottom, though partly blocked by hills and ridges of drift deposits, is much wider than in the upper parts where the bedrock is almost completely concealed by glacial drift in which the present stream channel is cut. Below the lower canyon, in which there is a fall of 40 feet in about one-quarter mile, the stream flows across the broad flats of Swift river. A wagon road, now in disuse, extends from Stanley and down Fountain creek to Swift river.

In the early days the canyons of the creek were flumed and the bedrock was cleaned, but there was, apparently, no attempt to mine the buried channel of the creek until 1905 when the Fountain Creek Mining Company was organized by J. D. Peebles for this purpose. Angus McPherson was foreman and mining development work was carried on for four or five years. Two shafts were sunk on the main branch, one about one-half mile above the forks and a second a few hundred yards above the forks, but were lost because of underground water pressure. A third was sunk 52 feet to bedrock and 23 feet in bedrock at the forks, and a tunnel was driven upstream about 500 feet. The tunnel was above bedrock except near the shaft and near the upper end where the channel was crosscut. J. F. Williams, who had an interest in the work, states that small amounts of fairly coarse gold were found, but no definite pay-streak. The tunnel was run mostly in clay, but gravels were found in places beneath the clay. The shaft was equipped with a water-wheel and a 10-inch Cornish pump. Development work was also done, about 1914, a short distance above the Lower canyon by Julius Powell and J. F. Williams. Williams at present holds the properties on the creek. A tunnel about 300 feet long was run into the bank below the basin on the east side of the stream to determine whether a buried channel of the creek occurs alongside the present channel. A ridge of glacial gravels and boulder clay, the highest part of which is about 100 feet above the creek, extends diagonally across and up the valley on the east side of the stream, and the tunnel was driven beneath the ridge and started on a rock bench a few feet above the level of the creek. The tunnel was not on bedrock all the way so that it is possible a buried channel exists, but very little gold appears to have been found in running the tunnel. Fine gold occurs in gravels along the sides of the present stream for a short distance upstream from where the tunnel was run and was derived by erosion of the gravel banks farther up the gravel ridge into which the stream has cut between the two canyons. Some gold was found in places on the rock benches where the rock is hard and rough, on the east side of the creek opposite and below the end of the gravel ridge, where it has been cut away by the stream. It would appear, therefore, that the gold was derived by erosion of the gravel ridge through which the present stream has cut, and, as a thickness of about 80 feet was probably cut away, the amount of concentrates of gold in the stream bed, unless they were much higher than has generally been supposed, indicates that the average gold values in the gravel ridge are probably very small. The question whether a buried channel exists does not appear to have been definitely settled and in any case so little coarse gold has been found in the basins of Fountain creek and the headwaters in general of Swift river that the occurrence of a rich pay-streak in the buried channel seems improbable.

Upper Swift River

Upper Swift river is reached by the trail from Stanley which extends up Last Chance creek to the head of Peters creek and down Fountain creek. The trail comes to Swift river at a point one-eighth mile below the junction of Little Swift and Swift rivers. Fountain creek joins Swift river about one-half mile below the trail crossing, and Porter creek, coming from the south, about 6 miles below. The positions of these tributary streams are shown incorrectly on existing maps. The alluvial flat of Swift river below the junction of Little Swift is about one-half mile wide and extends downstream for several miles. It is only sparsely timbered. Near the junction there are a few low hills of glacial drift rising above the valley flat. Upstream from the junction the valley flats of the two streams continue for several miles, but gradually narrow upstream. There is a rock canyon on Little Swift river near the mouth of the tributary Foster creek. Little Swift heads in Bald Mountain plateau near the sources of Antler creek, flowing in the opposite direction, and Swift or Big Swift farther south near the sources of Keithley creek. Below the junction, the stream at low water averages about 30 feet in width and 1 to 2 feet in depth and has a flow of 30 to 40 cubic feet a second. It flows over a bed of fine gravel with few stones over 6 or 8 inches in diameter. Flood-plain silt 1 to 3 feet thick overlies the gravel along the sides of the stream.

Some gold was obtained in the early days on Little Swift river just below the canyon, and one or more shafts were sunk in the deep ground of the creek, but it is stated that nearly all the gold was fine and was confined to the surface deposits. Parts of the valleys of Little Swift and Swift rivers have been staked once or twice in recent years as possible dredging ground. In 1919 a number of borings with rods were put down by Captain Edgar for an English company, to test the character of the ground. One cross-section of four holes was made across the valley near the junction of Little Swift and Swift, and another of four holes at the junction of Beedy creek, coming from Milk Ranch pass, and Little Swift river. The deepest hole was 24 feet deep and most of the others were 16 to 18 feet deep, at which depths cemented gravel is said to have been struck. Colours of fairly fine gold, some of which, however, is as coarse as 5 to 10 to the cent, can be obtained by panning on the bars of Swift river below the junction, but the average gold value and thickness of the gravels, and the extent of cementation, are not known.

Lower Swift River

Lower Swift river, above the junction with Lightning creek, below which the combined streams are known as Cottonwood river, flows in a broad, flat-bottomed valley for about 2½ miles. The valley flat in this stretch averages about 1,500 feet in width. Three-quarters of a mile above the junction a narrow drift ridge extends diagonally across the valley, and at the end of this ridge, on the west side, there is a shallow rock canyon in which the present stream flows. Another narrow rock canyon begins 1½ miles upstream and a half mile farther up there is a wider and deep rock canyon bordered by drift hills and ridges on both sides. There are, for several miles above the upper big canyon, no valley flats along the stream.

What appears to be a very good piece of dredging ground, though of no great extent, has been proved by drilling in the valley flat extending for 1½ miles above the lower rock canyon. The three-quarter mile stretch below forms part of Boyd's hay ranch and may also contain some gold, as may the shallow flats along Lightning creek for some distance above the junction. The ground on lower Swift was drilled in 1922 for G. A. Dunlop, to whom the writer is indebted for information regarding the results. In all, thirty-six holes were put down. All the gold is in the surface gravels, which average 13 feet in thickness and have a maximum depth of about 25 feet. Two or three holes were put down about 75 feet, but did not reach bedrock, the surface gravels being underlain by hard silt and boulder clay carrying no gold. Mr. Dunlop estimates that the drilling proved approximately 4,000,000 yards of ground having an average value of 31 cents a cubic yard. The surface is fairly heavily timbered in places, but a large part is grass land. The surface gravels are fairly coarse, but contain few, if any, large boulders. The gold is concentrated mainly on the clay, the surface of which is nearly level, and is mostly flaky, but not very fine, and is easily saved. The property is reached by a good wagon road turning off from the main highway at Cottonwood. A suction type of dredge was installed in the autumn of 1924 by Messrs. Kerr and Rowe, but it is hardly to be expected that favourable results can be obtained from such a type of dredge, and it is unfortunate that such dredges should be used when standard types are available. It is probable that a bucket dredge capable of digging to the required depth and with an estimated capacity of 60,000 yards a month can be placed on the ground for $180,000, and that actual dredging expenses should not exceed 10 cents a cubic yard. There is plenty of wood for fuel in the vicinity. The river has a swift current and at low water averages about 100 feet wide and 1 foot deep. At high water it is 150 to 200 feet wide and 4 or 5 feet deep.

Some drilling was also done in 1922, about 9 miles up Swift river, by the Cariboo Exploration Company, an Alberta company organized by H. C. Foster. Alfred Brown, Barkerville, was in charge. A cross-section of nine holes was put down, but the results were disappointing as the material was found to be mostly surface muck underlain by a thick stratum of clay containing no gold. One hole was put down 100 feet and bedrock was not reached. A wagon road extending up the east side of the creek leads to the property.

Peters Creek

Peters creek, the lower part of which is shown on Figure 30, is about 8 miles long and flows northwest into Lightning creek, which it joins about three-quarters of a mile below Beaver Pass House, where the valley flat of

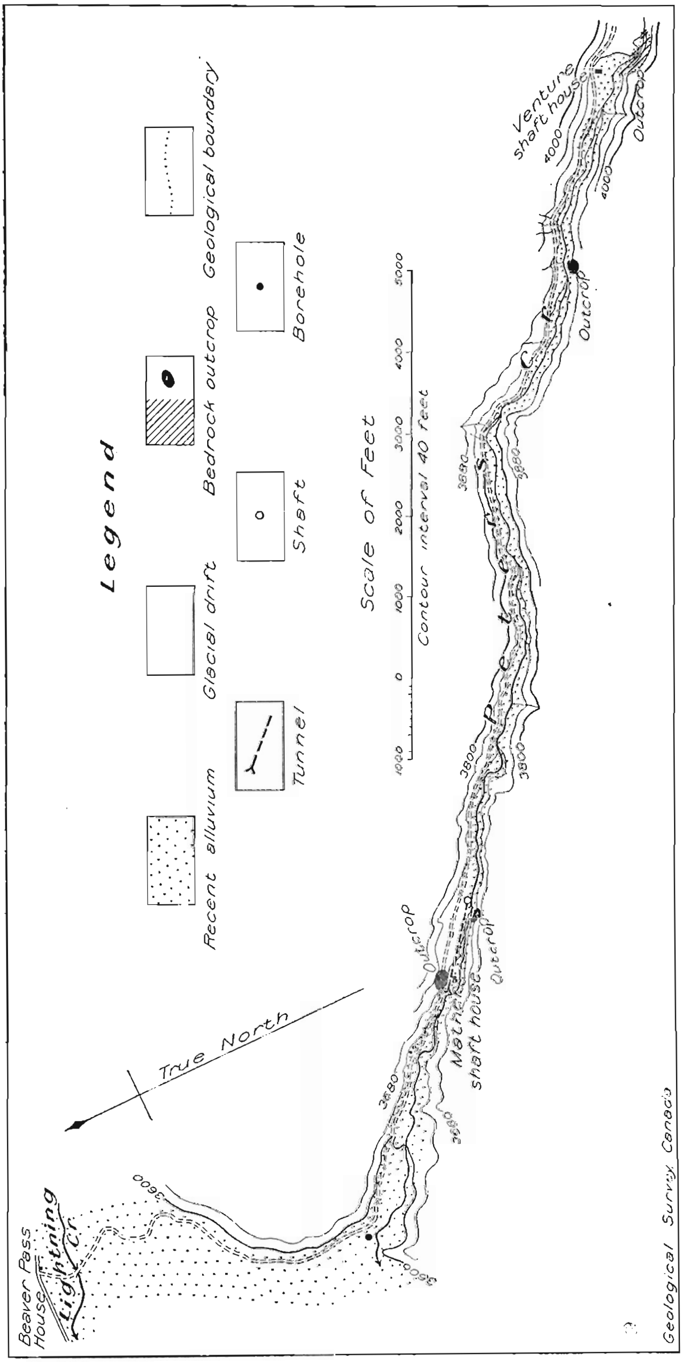

Figure 30. Peters creek, Cariboo district.

Lightning creek is over 2,000 feet wide. The stream flows in a comparaively narrow, drift-filled valley for $2\frac{3}{4}$ miles up from Lightning Creek flats. At the Mathers shaft, three-quarters of a mile upstream, the valley is somewhat constricted by a ridge of hard rock which outcrops on the east side. A short distance above the Venture shaft, $2\frac{3}{4}$ miles upstream, the creek flows in a shallow rock canyon on the west side. Drift, morainic ridges, block the main valley for about one-quarter mile. A small stream, at the mouth of which some mining was done in the early days, comes in from the northeast one-quarter mile above the Venture shaft, and $1\frac{1}{2}$ miles farther up the main stream is joined from the southwest by Campbell creek, on which considerable mining was done, especially in the lower part where the ground is shallow and was mined to bedrock by open-cuts. In the upper part some work was done in 1922 and 1923 by Paul Barnette and William Slade who obtained about $200 in gold, including a 5-ounce nugget, by ground-sluicing the surface gravels. About three-quarters mile up the creek, they attempted to sink a shaft through boulder clay to bedrock, but a heavy flow of water came in at the 35-foot level, when the shaft had reached a depth of 42 feet, and the work was abandoned. Higher up Peters creek, Carruthers and Basford (Basswood) creeks, both of which have been mined to some extent, come in from the northeast. The fact that several of the tributaries of Peters creek were known to be gold-bearing, at least to some extent, has led to several attempts at mining the deep channel of Peters creek. The ground on the creek is shown by borings and shafts to be at least 125 feet deep where the stream issues into Lightning Creek flats, 70 feet at the Mathers shaft, 35 feet at the Venture shaft, and 37 feet three-quarters of a mile farther upstream. The surface grade of the creek from the Venture shaft to Lightning Creek flats, a distance of 15,000 feet, is 2·15 per cent. The average grade of the bedrock channel from the Venture shaft to the Mathers shaft is 2·3 per cent. The average grade of the bedrock channel from the Mathers shaft to the bore-hole near the mouth is 4·1 per cent, and the ground may be somewhat deeper near the bore-hole. The bedrock channel of the creek, therefore, is much steeper in the lower part than in the upper, which suggests that the main valley of Lightning creek was somewhat over-deepened by ice erosion. The deposits in the valley of Peters creek consist of surface stream-gravels underlain in places by clay and in other places by glacial gravels. A peculiar kind of clay known as "swelling clay" occurs on the creek, especially along the west side from near the Mathers shaft to about 2,000 feet above the shaft. Terraces are cut in it above the shaft and the long tunnel starting near the Mathers shaft was run in it. Similar clay is known to occur at only one or two other places in the area. In running tunnels through it, the material had to be shot out a set at a time, for it is fairly hard and quite dry except near the surface. On exposure to the air in the tunnel the clay swells to such an extent that the timbering of the tunnel is likely to be broken. After a few days, the clay ceases to swell and the mine timbers may safely be replaced, for no further swelling occurs. The clay contains no stones, is not calcareous, is exceedingly fine grained and plastic, and shows only faint stratification. The clay swells on exposure to the air because it contains a great deal of colloidal or very fine-grained material, which enables it to absorb from the air sufficient moisture to increase its bulk several times.

No good sections of the clay are exposed, but it appears to be overlain by boulder clay. The fine-grained and homogeneous character of the clay, unlike that of the glacial silt, suggests that it may be pre-Glacial in age. The gravels seen on bedrock in the workings at the Mathers shaft are mostly Glacial, but may be partly pre-Glacial. The shaft is said to have passed through about 11 feet of surface gravels underlain by boulder clay and glacial gravels. At the Venture shaft the valley filling consists almost entirely of gravels, and similar conditions probably exist for some distance downstream. The following account of mining and prospecting on Peters creek is based mainly on information obtained from J. Gardiner, Beaver Pass House, who holds one of the leases on the lower part of the creek, from L. Ford, Barkerville, who was foreman at the Venture mine; and from W. E. Thorne, in charge of the recent drilling.

Drifting the deep channel of Peters creek began in the seventies, but only at the Mathers, Venture, and, possibly, at one other shaft at the mouth of the first tributary above the Venture was mining actually done. Several long tunnels, one of which is shown on Figure 30, were run, but they did not reach bedrock. What is now known as the Mathers shaft was sunk in the seventies nearly, if not quite, to bedrock. In 1905 the Premier and White Star companies, under the management of J. G. Mathers, reopened the mine and equipped it with a water-wheel and a $6\frac{1}{2}$-inch Cornish pump. The long tunnel starting below the shaft was run by the same company in 1900 and 1901. In 1906 and 1907 about 300 feet of drifting was done from the shaft. No further work was done until 1921, when the Construction Mining Company, J. M. Steele, manager, again opened the mine and drifted about 250 feet. Gold values as high as, or possibly more than, $6\frac{1}{2}$ ounces to the set with 6-foot caps are said to have been obtained, but the average was probably much less. Mining work on the Venture was carried on from 1908 to 1911. A shaft was sunk 20 feet to bedrock and 24 feet in the rock and a drive of 80 feet was made towards the channel. It was then realized that the tunnel was too low, and boring was done to determine the depth of the ground. The borings showed it to be only 35 feet deep. An upraise was then made from the tunnel and a drift carried downstream as far as the grade of the bedrock would permit and the channel crosscut. About 100 feet of drifts, 6 by 7 feet, were made in the channel and a little over $500 in gold recovered. Although the shaft was equipped with a water-wheel and a 10-inch Cornish pump, some trouble was experienced with water because of the porous character of the gravels. In 1922 George C. Hogg, Portland, Oregon, examined the ground on the creek from the mouth of Campbell creek to Lightning Creek flats, covered by leases optioned to the Construction Mining Company, and estimated that the ground contains over 3,000,000 yards, averaging nearly 50 cents a cubic yard. One bore-hole (shown on Figure 30) was put down to bedrock in the lower part of the creek. The bedrock gravels in the Mathers driftings were sampled, as well as the materials from the surface down to bedrock in the shaft, and numerous test pits were sunk in the surface gravels. In the spring of 1924 boring to determine the dredging possibilities of the creek was done under the direction of W. E. Thorne for C. A. Banks, Vancouver, manager of the Kafue Copper Development Company, which is operating the dredge on Antler creek. One cross-section of three holes was put down about 1,200 feet below the Mathers shaft, another of five or six holes, one-half mile above the shaft, and two cross-sections, of five or six holes each, one about one-quarter mile above the Venture shaft and the other one-half mile farther upstream. Mr. Thorne states that some gold was obtained in the surface gravels and in the bedrock gravels and that very fair values were obtained in a few of the holes, but that the average value of the ground is much less than as estimated by Mr. Hogg. Mr. Thorne estimated that there is possibly 1,000,000 cubic yards of 30-cent ground in the middle section of the creek, the average depth of the ground being 35 feet.

QUARTZ VEINS

GENERAL STATEMENT

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 which 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. For these reasons it is considered advisable to give a chronological résumé of the lode mining, mentioning only the most significant steps in the development, along with some of the annual criticisms and observations of the Government agent and other officials.

CHRONOLOGICAL RÉSUMÉ OF LODE MINING[1]

1876. "Efforts should be made to regain, if not all, at least a portion, of the prosperity which prevailed in former years, by developing the rich quartz veins which abound throughout the district. The first step in this direction has been recently taken to secure the benefits arising from this permanent source of wealth. A company has been organized for the purpose of testing and working the ores taken from the various ledges in the vicinity."

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. "In May last, the Provincial Government—in addition to having offered a bonus, under certain conditions, to the company which should first erect a 10-stamp quartz mill in Cariboo—wrote to Mr. Booker, Her Majesty's Consul at San Francisco, asking him if he would kindly employ, on its behalf, the services of 'some person skilled in quartz.' The province was indeed fortunate in Mr. Booker's selection, for Mr. Harper's great knowledge and experience in lodes and ores are undoubted, and have been of the greatest possible use in the, so far, successful developments which have been made during the past season. A year ago, the miners of Cariboo, after long and patient struggling, had nearly given up all hope; to-day everybody is looking forward to an era of prosperity which, in the opinion of the well-informed, will even exceed that of the palmy days of 1862–3–4–5. ....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........

"Believing that quartz mining in this district is destined to take precedence in the future, I have endeavoured to ascertain the approximate cost of working the ledges, and find, upon the best information obtainable, that mining and milling the ore with a ten-stamp mill will cost from $10 to $12 per ton, which will vary according to circumstances."

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[1]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.

(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.[1]

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.[2]

The Foster mine, Chisholm creek, has a shaft 18 feet deep with promising indications.[3]

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 of 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."

1879. With the exception of J. C. Beedy's location on Burns mountain all companies have suspended operations.

"Mr. Beedy keeps his small mill at Van Winkle running, crushing ore from his mine on Burns mountain which is, I understand, paying about wages."

1880. Quartz mining was entirely suspended, with the exception of a small amount of work done by the Enterprise Company upon their Island Mountain location. The Beedy quartz mine on Burns mountain was purchased by Jas. Reid of Quesnellemouth.

1881. No operations except the driving of a 600-foot tunnel, by the Fallis Company, on Burns mountain, strike their ledge (Perkins?) at a lower level.

1882. "With the exception of some tunnel work on Burns mountain, no prospecting for quartz was done. Samples of quartz taken from a ledge found on one of the tributaries of Willow river by Foster and Paris, assayed at the Government Assay office 15·07 per ton of 2,000 pounds, with traces of silver."

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

"We crossed over Willow river to the east side of it, a short distance above the junction of Valley creek with Willow river, and continuing down stream we camped at night on a small stream, which we subsequently named Beaver creek........ The next day we found a large quartz ledge, supposed to be the one discovered by Foster and Paris last season.

[1]From letter by R. B. Harper to Minister of Mines, contained in Ann. Rept., Minister of Mines, B.C., 1877.
[2]From letter by R. B. Harper to Minister of Mines, contained in Ann. Rept., Minister of Mines, B.C., 1877.
[3]From letter of Messrs. Schuyler Pearce and Shepherd to the Gold Commissioner, Richfield, Oct. 25, 1883.

"We spent several days prospecting this ledge, made a location, and took away with us samples to have assayed at Barkerville. The ledge is over 5 feet thick, crops out along the surface for about 600 feet, and dips at an angle of 45 degrees or thereabouts. Its direction, without making allowance for variation of compass, is 65 degrees east of north. The country rock is of slate and the ledge cuts through it nearly at right angles. About one-quarter of the vein is largely impregnated with argentiferous galena ore, assays from which gave $19.98 silver and traces of gold, and the quartz rock a small amount of gold per ton."

1884. Assay office at Barkerville closed.

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.

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

1885. Geological survey of the district by A. Bowman. No material development of the quartz ledges.

1886. "These gentlemen (Messrs. Koch and Craib, "mining experts from California") are quite agreed as to the manner of treatment to be pursued in the reduction of our ores, and when we consider the time, labour, and capital expended in the attempt made in 1878 to work our ledges, it seems almost incredible that those men who were placed in positions of trust as experienced quartz miners, did not introduce either concentrator or chlorinator, a "sine qua non," we are now informed, to the successful working of these ores.

"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.

1889. One trail test of ore from Black Jack mine was made in Reduction works. (For particulars see under description of Black Jack mine, page 24.)

1890. "The destruction by fire of the Government Reduction Works last winter had a most depressing effect upon this branch of our mining industry, but fortunately these works, although in operation but a few weeks, had proven their capability to successfully treat the character of ore found here, and consequently justified the Government in rebuilding the same upon a somewhat increased capacity, which undertaking has been accomplished most successfully under Mr. Martin's supervision, and the works are now in operation again. It is a fact worthy of note that the gross product of the district has been increased by about $5,000 produced from the working of quartz. The Black Joe Quartz Mining Company have during the season prosecuted work on their mine; their shaft being now down to a depth of something over 100 feet, and exposing a valuable body of ore. Their small prospecting mill was kept running a good part of the time until stopped by frost. This company has taken another lot of sulphurets to the test works, which is now under treatment. A most satisfactory test of the ore from this mine was made at "The Cassell Gold Extracting Company's Works," Glasgow, Scotland. From 360 pounds of ore sent, a result of something over $80 per ton was obtained; the ore worked up to 90 per cent of the assay value.

"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 partially remedied. Some fifteen or twenty tons of sulphurets were saved and brought to the Government Works for treatment. I learned that...... the test cannot be regarded as a fair result, inasmuch as the ore was taken from the dumps at the various tunnels belonging to the Company, and was mostly surface rock."

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.

1893. No development.

1894. No development.

1895. S. J. March bonded the Black Jack claim and the Reduction Works.

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

1896-1901. During this period no development work worth mentioning has been recorded as having been done on the veins.

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 have 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. Having installed a complete assaying plant and laboratory at Barkerville, they have been engaged in making tests of the ore taken from a number of the most promising ledges. On application, 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.

1907-1911. No mention of any lode mining or development in the Annual Reports.

1912. Assessment work on some of the veins was accomplished. R. R. Hedley baled and examined the workings of the B.C. Milling and Mining Company's mine.

1913. No mention of work on quartz veins.

1914. Mr. C. J. S. Baker did practically the only work on quartz, on his three claims on Proserpine mountain.

1915. No mention of work on quartz veins.

1916. "This year a new ledge was discovered on the Grouse Creek side of the mountain (Proserpine) by Elmer Armstrong, and a number of claims were staked and a certain amount of work done."

1917. Assessment work only was accomplished on a few claims. The 1917 Annual Report contains a detailed description of the claims on Proserpine mountain, by J. D. Galloway, resident engineer for Mineral Survey District No. 2.

1918. Assessment work only was accomplished on a few of the claims.

1919. Mining Corporation of Canada spent considerable money under bond in a surface examination of the veins on Proserpine mountain.

1920. Mining Corporation of Canada relinquished its bond. Assessment work alone was done.

1921-1922. Nothing attempted except assessment work.

Messrs. A. W. Sanders and I. E. Moore did more than the amount of work required for assessment purposes on their Rainbow and Hudson groups respectively.

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 which 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,[1] 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 which 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,[2] but it is not apparent whether the more auriferous pyrite was derived from the A veins themselves, or from 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 194.)

(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

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

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 195–205.) 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 veins: (*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 (Plates XIV, XV); (*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.[1]

[1]Similar flowage structures in galena have been described by the writer in a paper entitled "Gneissic Galena Ore from the Slocan District, British Columbia"; Econ. Geol., vol. XII, No. 8, pp. 643–662 (1917); by. F. L. Ransome from the Coeur d' Alene District, Idaho, in U.S. Geol. Surv., Prof. Paper 62, p. 91; by Whitman Cross from the Minnie Moore mine, Colorado, in Proc. Colo. Sci. Soc., vol. II, p. 172 (1887); by Lindgren and Irving from Pammelsberg, in Econ. Geol., vol. VI, pp. 303-313 (1911). Specimens showing exactly similar autoclastic relations between quartz, siderite, and galena, from the Alpha mine near Golden, British Columbia, have been shown to the writer by H. G. Nichols, Vancouver, B.C.

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, [1] 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

[1]Walker, T. L.: "Report on Tungsten Ores of Canada"; Mines Branch, Dept. of Mines, Canada, Pub. No. 25 (1909).

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 been 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:

Black Jack. This prospect 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 193.)

Independence-Kitchener. These 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.

Victory. Several small open-cuts on this 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.

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 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 which 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.

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.

There is no one now in Barkerville who worked in the mine or who has any first-hand information about the workings. The following information, therefore, taken from the reports of the Government agent, from the old company's letter book, and the superintendent's reports, is here presented.

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 concentrated 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 cross-cut 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 $425—$113 of this being in free gold, and $313 from 5 tons of concentrates. This represents an average recovery of $15.18 per 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, p. 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 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."[1]

"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."[2]

"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."[3]

"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."[4]

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."[5]

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,

[1] Ann. Rept., Minister of Mines, B.C., 1902, p. 110.
[2] Ann. Rept., Minister of Mines, B.C., 1897, p. 474.
[3] Ann. Rept., Minister of Mines, B.C., 1877, p. 396, from letter by R. B. Harper.
[4] Ann. Rept., Minister of Mines, B.C., 1887, p. 395.
[5] Geol. Surv., Canada, Ann. Rept., vol. III, pt. C, p. 32 (1889).

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 31, 32a, and 32b) 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. Working No. 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.

Working No. 2. A B vein 10 to 15 inches wide, striking north 55 degrees east, with pyrite, arsenopyrite, and galena.

Working No. 3. Irregular bunches of quartz containing some pyrite and arsenopyrite.

Working No. 4. Open-cut showing 9 feet of barren quartz of A type.

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

Working No. 7. Open-cut showing 13½ feet of shattered white quartz of A type, striking north 52 degrees west.

Wilkinson R. E. Claim. Working No. 8. Old shaft 50+ feet deep, with large dump showing white quartz with small amounts of pyrite. The following description is from the Annual Report, Minister of Mines, B.C., 1914, page 66. "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."

Proserpine Claim. Working No. 9 a. Old shaft 67 feet deep. The following description is from the Annual Report, Minister of Mines, B.C., 1914, page 66. "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."

Working No. 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.

Working No. 9 c. Old shaft 67 feet deep.

Working No. 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

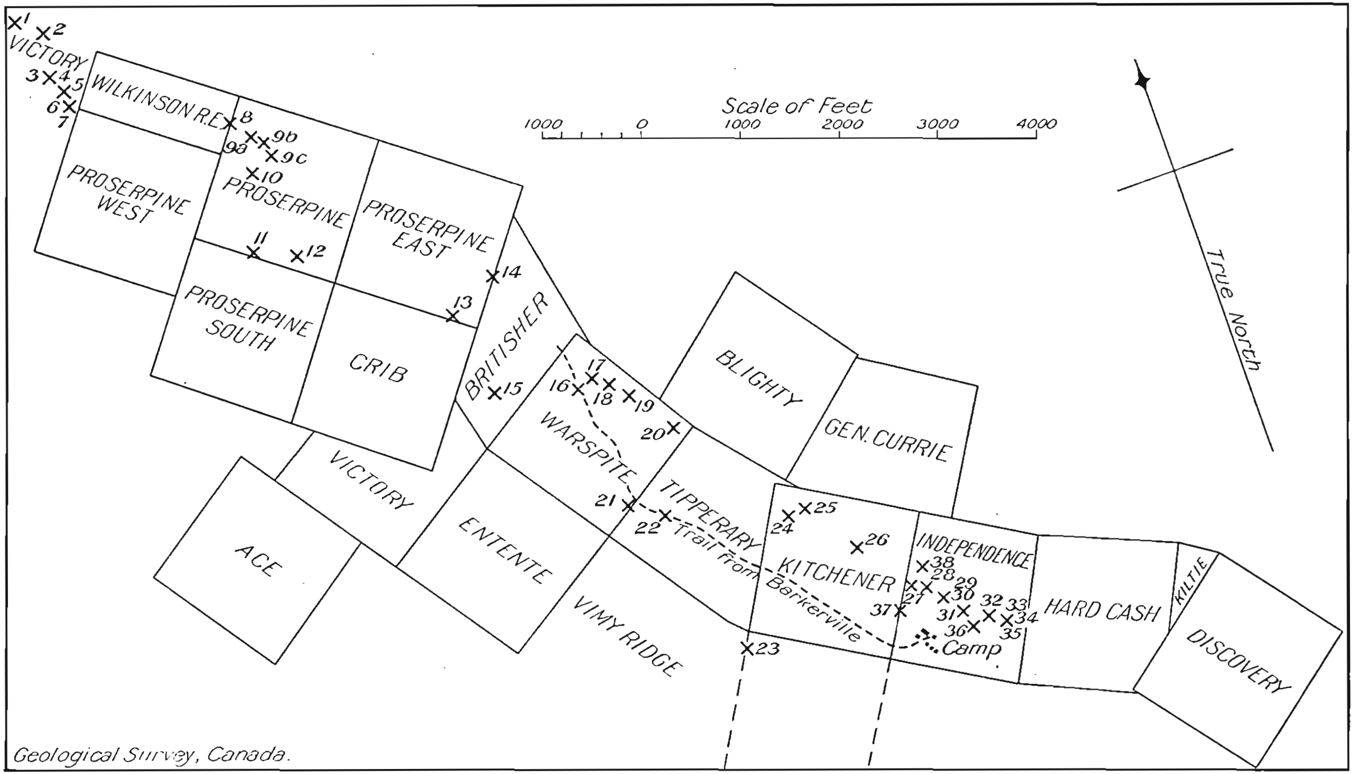

Figure 31. Index map showing principal mineral claims on Proserpine mountain and location of workings described in text. (*See also* Figures 32a and 32b.)

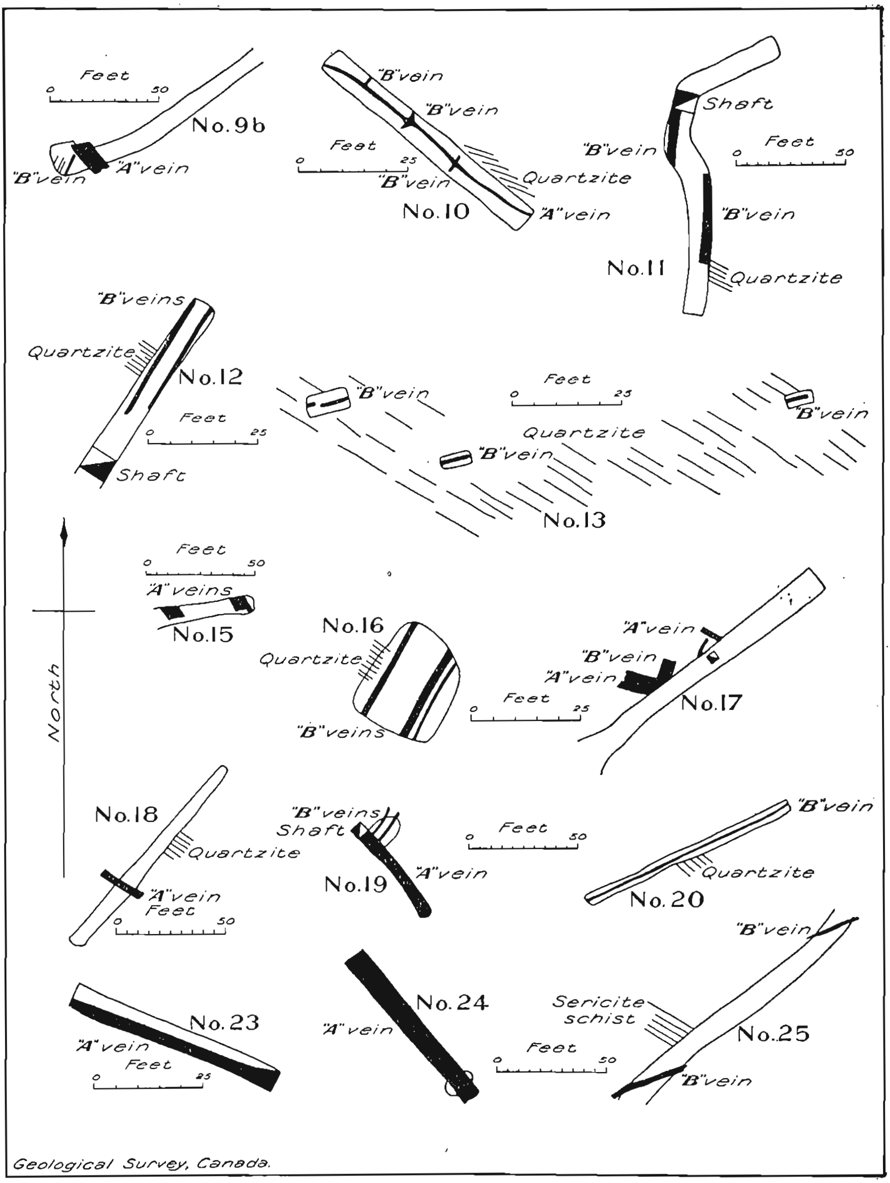

Figure 32a. Plans of workings on Proserpine Mountain mineral claims. *(See also* text and Figures 31 and 32b.)

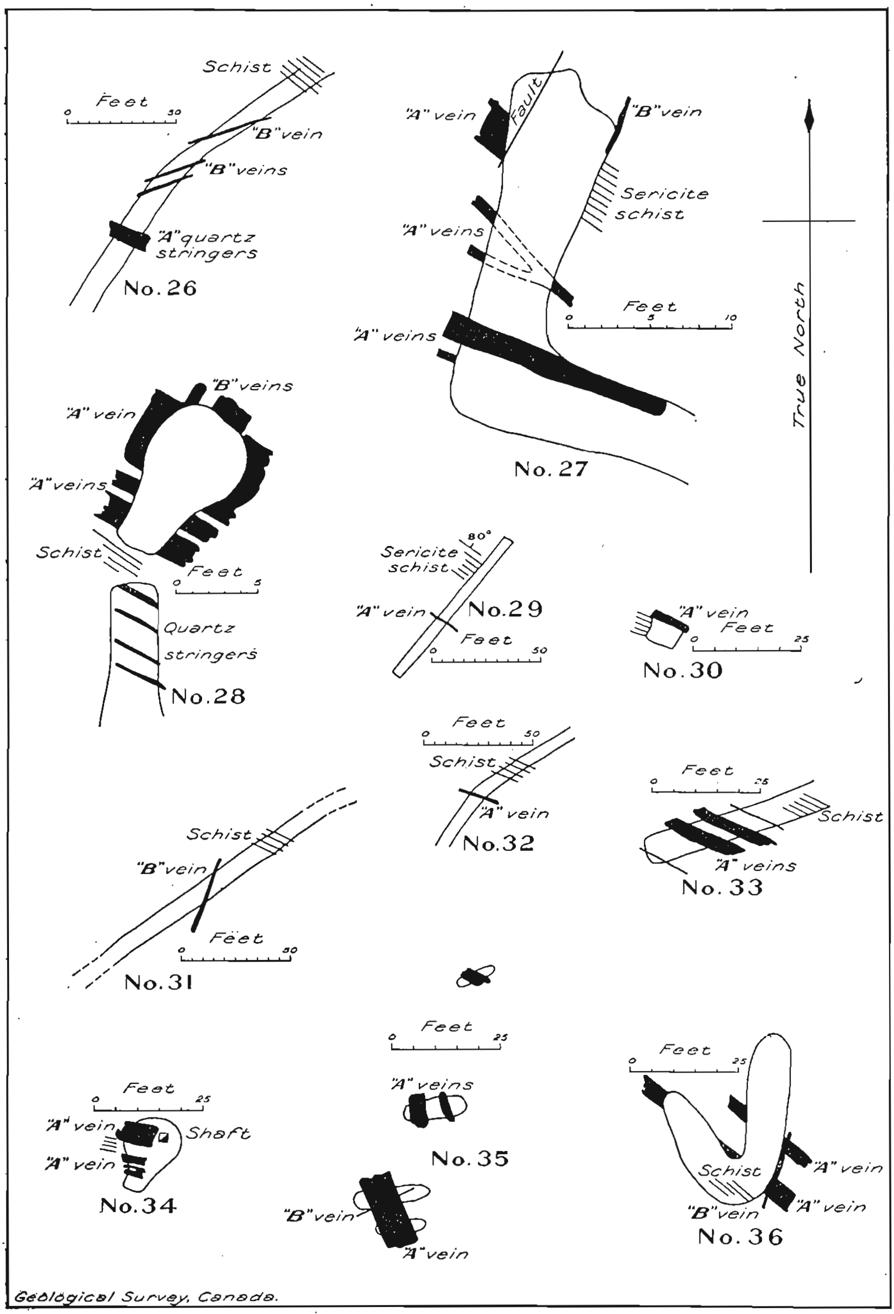

Figure 32b. Plans of workings on Proserpine Mountain mineral claims. *(See also* text and Figures 31 and 32a.)

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.

Working No. 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 following description is from the Annual Report, Minister of Mines, B.C., 1914, page 66. "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."

Working No. 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. The following description is from the Annual Report, Minister of Mines, B.C., 1914, page 66. "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."

Proserpine East Claim. Working No. 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.

Working No. 14. Two small open-cuts expose a set of irregular quartz stringers containing pyrite and arsenopyrite.

Britisher Claim. Working No. 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. Working No. 16. A small open-cut in quartzite striking southesterly. 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.

Working No. 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 is visible.

Working No. 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.

Working No. 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.

Working No. 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. Working No. 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. Working No. 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. Working No. 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.

Working No. 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.

Working No. 26 is 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 $4\frac{1}{2}$ 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. Working No. 27 is 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 $2\frac{1}{2}$-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.

Working No. 28 is 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 $2\frac{1}{2}$ 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.

Working No. 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.

Working No. 30 is a small pit in schist and shows $1\frac{1}{2}$ feet of quartz lenses and soft, black gouge, separated by 2 feet of schist from $1\frac{1}{2}$ 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.

Working No. 31 is 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.

Working No. 32 is 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.

Working No. 33 is 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 $6\frac{1}{2}$-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.

Working No. 35 consists of 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 $3\frac{1}{2}$ 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.

Working No. 36 is a curved open-cut in schist striking southeast. An A vein $3\frac{1}{2}$ 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.

For further information concerning the character of the veins opened up since 1915, the reader is referred to descriptions of the claims by J.D. Galloway, resident engineer for the Northeastern Mineral District (No. 2), British Columbia.[1]

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

[1]Ann. Repts., Minister of Mines, B.C., 1917-1922.

of selection of each sample, as well as its metal content, is 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	
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	....	

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
Warspite—Con. 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, honey-combed 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."[1]

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[2] 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.

[1]Ann. Rept., Minister of Mines, B.C., 1897, p. 474.
[2]Geol. Surv., Canada, Ann. Rept., vol. III, pt. C. pp. 34-37 (1889).

"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 view 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."[1]

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."[2]

[1]Ann. Rept., Minister of Mines, B.C., 1902, pp. 111-112.
[2]Ann. Rept., Minister of Mines, B.C., 1902, p. 110.

"The vein matter carries a large quantity of iron, blende, and lead. Assays thereform vary from $16 to $20 per ton."[1]

"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."[2]

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."[3]

"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."[4]

Enterprise Ledge

Bowman 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."[5]

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

[1]Ann. Rept., Minister of Mines, B.C., 1877, p. 396.
[2]Ann. Rept., Minister of Mines, B.C., 1877, p. 396.
[3]Ann. Rept., Minister of Mines, B.C., p. 1877, 395.
[4]Ann. Rept., Minister of Mines, B.C., 1902, p. 111.
[5]Geol. Surv., Canada, Ann. Rept., vol. III, pt. C, p. 34 (1889).

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."[1]

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.

[1]Geol. Surv., Can., Ann. Rept., vol. III, pt. C, p. 38 (1889).

Hardscrabble Creek Scheelite Ledges

"Introductory. 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. McPherson, 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."[1]

"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."[2]

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 by J. D. Galloway.

[1]From Report by J. D. Galloway in Ann. Rept., Minister of Mines, B.C., 1918, pp. 135-136.
[2]From report on "Tungsten Ores of Canada," by T. L. Walker, Mines Branch, Department of Mines, Canada, 1909.

Sam Montgomery's Ledge

Bowman 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 ledge 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]

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 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."[2]

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."[3]

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.

[1]Geol. Surv., Canada, Ann. Rept., vol. III, pt. C, p. 39 (1889).
[2]Geol. Surv., Canada, Ann. Rept., vol. III, pt. C, pp. 32-33 (1889).
[3]Ann. Rept., Minister of Mines, B.C., 1877, p. 396.

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 an assay on 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 is 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," above-mentioned.

CHAPTER IV

ORIGIN OF THE PLACER GOLD

STATEMENT OF THE PROBLEM

The question of the source of the placer gold in Cariboo district, British Columbia, has been one of interest to mining men and prospectors almost since the discovery of the placers. The fabulous richness of the placers in certain restricted parts of several of the creeks—2½ miles of Williams creek and its tributaries, for example, being credited with a production of about $19,000,000[1]—and the coarseness and angularity of much of the gold were strong indications that the placer gold was of decidedly local origin. After the exhaustion of the richer parts of the gravels in the seventies, the attention of the prospectors was directed towards a search for the mother lode. The only occurrence of auriferous lodes in the region is a belt of quartz veins which crosses the drainage basins of the creeks, and deposits located in this belt were prospected by means of tunnels and shallow shafts. Free gold was found only in the upper, disintegrated, and decomposed parts of the veins, but not in quantities that seemed large enough, nor of the proper character, to be the source of supply of the gold for the rich placers.

The problem of the origin of the placer gold, therefore, should be solved by the answers to the following questions:

(1) Was the placer gold derived from these auriferous quartz veins?

(2) Are the quartz veins, as at present exposed, merely the roots of deposits whose upper eroded parts contained very much greater quantities of primary free gold?

(3) If not, and assuming that the upper eroded parts of the veins contained minerals similar to those of the parts non-exposed is there any evidence to show that the placer gold might have been derived from the veins?

(4) If the evidence points in the direction just indicated, what combination of processes could explain the derivation of the placer gold from the veins?

(5) Does the geological and physiographical history of the region show that conditions were favourable for such a derivation?

SUMMARY OF CONCLUSIONS

(1) The placer gold of the region is derived from a belt of auriferous quartz veins.

[1] Ann. Rept., Minister of Mines, B.C., 1896.

(2) The auriferous constituents of the unoxidized parts of the veins are the sulphides, arsenopyrite and pyrite. There is no evidence that the eroded parts of the veins were richer in primary free gold than the remaining parts. It is probable that they contained minerals similar to those of the lower parts.

(3) Deep decomposition of the veins permitted oxidation of the sulphides and removal of the soluble constituents. Part of the fine gold thus set free from the sulphides formed enrichments in the oxidized parts of the quartz veins. Gold enrichment also took place by a process of alternate solution and deposition of the free gold in the form of crystals, crystal groups, plates or veinlets, and irregular masses, in cracks and cavities in the veins and adjacent country rock near the base of the zone of oxidation. The crystal groups, plates, and irregular masses thus formed, and subsequently modified by the action of the streams, are the main source of the nuggets in the gravels.

(4) The processes by which alternate solution and deposition of the gold took place are not definitely known, but it is probable that removal was effected chiefly by chloride solutions. Abundant precipitants in the form of siderite, pyrite, and carbonaceous material are present.

(5) During late Cretaceous and (or) early Tertiary time the area was being reduced to one of low relief—possibly under semi-arid conditions—and, therefore, conditions were suitable for deep secular decay, for slow removal of the products of decomposition, and for gold enrichment in the oxidized parts of the quartz veins. In late Tertiary time, uplift of the region caused rejuvenation of the streams. Deep valleys, which, for the most part, coincided with the ancient valleys, were cut and in them the gold, liberated in the zone of Tertiary weathering, was concentrated.

(6) In Pleistocene time ice-sheets covered the region, but were stagnant and, therefore, accomplished little erosion; valley glaciers were not sufficiently extensive or long-lived to be effective agents of erosion except in parts of the region, and the valley bottoms in places were protected from erosion because of the narrowness of the valleys and the presence of outwash gravels overlying the Tertiary gravels. A small part of the Tertiary placers, therefore, was preserved. Some of the placers are post-Glacial and others interglacial and Glacial in age, and are the result of concentration by streams, of the gold in gravels, which were derived by ice-erosion of the Teritary gravels, and thus became included in the glacial drift. The Tertiary weathered zone of rocks was largely removed by ice-erosion, but, in places, deeply weathered rocks occur beneath unweathered glacial drift, and, as little post-Glacial weathering has taken place, it is probable that the upper oxidized and highly fractured parts of the veins containing free gold are, in part, remnants of the Tertiary belt of weathering.

EVIDENCE OF THE DERIVATION OF THE PLACER GOLD FROM THE BELT OF AURIFEROUS QUARTZ VEINS

The placer gold occurs, along with concentrates of other heavy minerals such as pyrite, galena, scheelite, barytes, most abundantly in poorly assorted angular and partly rounded gravel mixed with yellow or blue clay, derived from disintegration of the gravel, in broken and partly disintegrated bedrock (in part ancient talus or "slide-rock"), and in cracks in the bedrock in the bottoms of the stream channels. A large part of the gold is in the form of only slightly worn crystals, crystal groups, plates, and irregular masses, which certainly have not been transported very far. The association of quartz, galena, and pyrite with gold in the nuggets also proves that the amount of transportation has been slight.

Small crystals and crystal groups of gold, similar to those found in the stream gravels, occur in the upper oxidized parts of quartz veins within the drainage basins of the creeks. Crystals with hopper-shaped faces are found in many places under both conditions of occurrence.

Pebbles of foliated galena and scheelite occur abundantly in the gravels; they are found also in the auriferous veins.

The great part of the gold from each creek is known to possess fairly definite characteristics. This feature is so marked that the old merchants who handled a great deal of the gold could tell by inspection the creek or creeks from which various specimens were obtained. A small part of the gold—apparently derived from the drift—is usually of a different character and some creeks have different kinds of gold in different parts. The fact, however, that much of the gold from each creek has fairly definite characteristics shows that it is derived locally. Many of the nuggets, also, are too large to be transported any great distance by streams, and it is probable that they have moved vertically downward nearly as far as they have been transported horizontally.

There is a close areal relationship between the upper limits of the rich placers of the various creeks and the location of the northwesterly-trending belt of auriferous quartz veins. This was emphatically indicated in 1888 by Amos Bowman[1], who outlined on his map of the area, the boundaries of the rich placers and showed their relationship to the quartz veins.

There can be little doubt, therefore, that the gold of the placers was derived from the auriferous quartz veins, the main problem being to determine how the placer gold could have been derived from quartz veins of such character as those found in the Barkerville area.

CHARACTER OF THE PLACER GOLD

Very little flour gold or even fine scale gold occurs in the area, apparently because of the high gradient of the streams. In several of the valleys the gold is progressively finer downstream and coarser in the upper parts, where, however, there is no assortment into sizes, heterogeneity of both size and shape being the rule. Flattened grains and pellets up to one-twentieth inch in diameter are abundant. Nuggets of various weights up to about 37 ounces have been found and are commonly well-worn, but many are only slightly worn and contain embedded in them grains of quartz or pyrite.

[1] "Report on the Geology of the Mining District of Cariboo, B.C."; Geol. Surv., Canada, Ann. Rept., vol. III, pt. C (1889).

Gold Nuts

Many specimens show crystal forms. These are usually the dodecahedron and groups of dodecahedrons. Cubes and octahedrons are also observed. Some of the angular material shows a columnar structure, the result of incipient crystallization. Most of the crystal specimens show some rounding, indicating wear rather than growth in the gravels. The slight amount of wear is readily explained by the fact that the crystals occur in crevices in the bedrock and in slide rock (ancient talus) in the bed of the streams and, therefore, were protected from abrasion by the streams. They may have been included in cavernous or fractured quartz when introduced into the gravels and thus protected. A nugget weighing 5 ounces was obtained in 1923 by Paul Barnette and William Slade on Campbell creek. It consisted of a mass of arborescent crystal gold and was almost entirely unworn, although it was found in surface gravels overlying boulder clay and, therefore, must have been transported.

Some specimens consist of gold with small amounts of quartz, whereas others show a fragment of quartz with a small amount of gold in vein-like form through it. Others show many intermediate phases between these two end cases. Specimens, also, have been found consisting of brecciated quartz, of which the various fragments are held together by a vein-like cement of gold.

Thick plate-like pieces of gold with the edges and corners rounded, weighing up to 3 ounces, have been found. The sides of the plates show linear ridges of gold separated from one another by polyhedral depressions. The plates resemble fissure-fillings and the linear ridges represent veinlets of gold deposited in subsidiary cracks in the walls of fissures.

In many specimens the rugged protuberances on the more angular pieces of placer gold may be seen slightly rounded and bent over, just as one would expect them to be shaped in the transition from vein gold to placer gold. Many of the curved protuberances enclose in the concavity beneath them, angular fragments of quartz, which had not been separated from the gold by abrasion. When the bending of these salient parts of the angular gold has proceeded to a more advanced stage, the quartz grains become entirely embedded in the nugget. The mammillary character of the surface of many of the nuggets is probably explained by such a process.

One slightly worn piece of angular gold shows on both sides a number of triangular depressions shaped like the corner of a cube, from which crystals of pyrite have no doubt been removed.

Many specimens of galena, found in the placer deposits, show small amounts of free gold. Close inspection of several such specimens and of polished surfaces of them revealed the fact that the gold occurred in veinlets or in well-developed cleavage cracks in the galena or in re-entrant parts of the specimens. Gold i[n] gale[na]

One specimen, consisting of brownish sericite schist from the country rock of the region, showed veinlets of gold traversing the rocks, both parallel and transverse to the schistosity.

Polished and etched nuggets (Plate IX A and B) from the district show several features which throw some light on the origin of the placer gold. Nugget No. 1 (Plate IX A) shows crystal faces, but is somewhat worn; Nos. 2, 3, 4 are well worn. The nuggets when polished and etched show definitely a crystalline structure (Plate IX A) and it is probable, as has been found in other regions,[1] that nearly all the placer gold, as well as the vein gold, is crystalline, and only a small part concretionary. One nugget (No. 1, Plate IX A) is composite and consists of a large crystal occupying the middle part, with additional crystal growths at both ends. All the nuggets show cavities and inclusions. Two of the nuggets, Nos. 3 and 4, apparently contain gold of different fineness, one part being higher in silver than the other part. This is shown by the fact that when the surface is etched with aqua regia one part turns a persistent grey, whereas other parts remain bright. The contact between the two kinds of gold is an irregular, but sharply defined line (Plate IX B). The bright gold is not due to leaching of the silver content of part of the gold in the nugget, for, in places, particles of bright gold are completely enclosed in the greyish gold. A narrow band of bright gold around the outside of the nuggets, however, is probably due to leaching of the silver content. Assays of two pieces cut from a nugget were made by the Mines Branch, Department of Mines, Canada. The nugget was first treated with aqua regia to remove the outside part. Two pieces weighing about one-tenth gramme were then cut from the nugget in such a way that one piece contained a greater quantity of the bright-coloured gold than the other piece, but, because of the intimate relationship of the two kinds of gold, no definite separation could be made. The polished surface of the nugget, when slightly etched, showed, distinctly, patches of bright and dark-coloured gold; when thoroughly etched the whole surface turned dark, owing to the formation of a surface film of silver chloride, the nugget being high in silver. The results of the assays showed that one piece of the nugget contained 80·04 per cent gold and 18·33 per cent silver, and the other 81·37 per cent gold and 17·38 per cent silver. Though the evidence is not as definite as might be wished, it seems probable that some of the nuggets were formed by deposition from different kinds of gold solutions, and, therefore, by a process of gradual accretion.

The cavities and inclusion in the nuggets are probably partly due, as pointed out above, to modification of the shapes of the nuggets by the action of the streams. Some of the cavities are probably due to removal by solution of pyrite in the gold, this action having taken place, largely, during the time of formation of the nugget.

The placer gold varies in fineness from about 775 to about 950. The vein gold is said to vary in fineness from 850 to 910[2]. The marked difference in fineness of the gold of different creeks is probably mainly due to differences in the character of the vein gold, from which the placer gold was derived, and only slightly to the leaching of the silver content, for it is evident that the nuggets have been only slightly leached. There is no evidence that the placer gold is, as a rule, of greater fineness than the vein gold.

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[1]Liversidge, Jour. Roy. Soc., N.S.W., vol. XXVIII, p. 343 (1893); Ibid, vol. XXXI, p. 79 (1897); ibid, vol. XL, p. 161 (1906).

[2]Atkin, A. J. R.: "Some Further Considerations of the Genesis of the Gold Deposits of Barkerville, B.C., and the Vicinity"; Geol. Mag., vol. III, p. 518 (1906).

ACCRETION OF GOLD IN THE GRAVELS

The view held by some writers, that nuggets are formed by the rolling together or welding of gold particles by the action of the stream gravels, and the comparison which is made with the easy welding of gold in dentistry, do not appear applicable, for in order to secure good welding, it is necessary to use pure gold free from surface film. Placer gold is never pure and the particles usually have a surface film which would prevent welding. Moreover, the structure of the nuggets shows that they are not formed by the welding together of particles, but rather, that the gold was deposited from solution.

The formation of part of the placer gold by deposition from gold solutions in the gravels is possibly suggested by the occurrence of crystals and crystal groups, which are apparently too well formed to have been transported by the streams, by subangular and rounded pieces of quartz with thin platings or films of gold encasing them, and by the occurrence, in one of the hydraulic pits, of a rusty iron nail, to the side of which was firmly attached a small, rounded piece of gold. In the latter case it is not certain that the gold was deposited from solution. What probably happened was that the piece of free gold was pressed or hammered against a roughened surface of oxidized iron, by the action of the stream gravels. On the other hand the gold crystals are usually somewhat worn, and, as has been pointed out above, it is possible that gold crystals may have been derived from the oxidized parts of the quartz veins and included in the gravels without having been much worn. Fractured quartz cemented by gold may have been the source of the gold-plated pieces of quartz. The large accumulations of placer gold in places where the bedrock is favourable for retaining gold and around boulders, as pointed out by Atkin,[1] show that the concentrations were the result of stream action. The comparatively rapid flow of the ground water, due to the steep gradients of the streams, is unfavourable for deposition of gold from solutions in the gravels. It is probable, therefore, that under present conditions little if any deposition of gold from solutions can take place in the gravels. It is possible that deposition from gold solutions in the gravels took place formerly, when the streams had low gradients and the rocks were deeply weathered, but this action was probably of little importance.

QUARTZ VEINS

Two chief sets of quartz veins, which have been described as the A veins and the B veins, occur in the district. The A veins consist of large bodies of almost barren white quartz with a prominent cross-vein jointing. These veins strike northwest and are sparsely mineralized with pyrite carrying low values in gold. The B set of veins strikes northeasterly and crosscuts the A set. They are predominantly narrow—from a fraction of an inch up to 4 or 5 feet in width—but there are very many of them. In many places they are closely spaced. They are usually well mineralized with galena, arsenopyrite, pyrite, and siderite and carry in places some

[1]Ibid, p. 516.

quantities of scheelite, sphalerite, and pyrrhotite. At the junctions of the two sets of veins there are usually developed chutes of sulphide minerals of considerable size.

The A veins occur in the "belt of veins" trending northwest and crossing the creeks near the upper limits of the rich placers. The chutes, therefore, are strung out intermittently along this belt where the B veins intersect it.

Some of the larger and more barren veins of the A class outcrop prominently along the valley slopes and on the grassy meadows of the upland. Most of the veins of the B class and all the mineralized intersections are buried beneath drift. Veins of both types have been prospected for gold, but except for a few small shipments made over twenty-five years ago, none of these deposits has developed into a producer.

Free gold may be recovered by panning or rocking the upper, disintegrated and oxidized parts of many of these veins. The amount of gold thus obtained varies greatly from vein to vein. The veins in most cases are shattered and the sulphides are oxidized to various depths up to at least 50 feet. Free gold has been found only in this belt of weathering. In the zone of unaltered sulphides below, the gold values are almost entirely in arsenopyrite and pyrite.

Selective sampling of the sulphides in the veins showed that: (1) as a general rule the galena is not auriferous, but carries from one-third to one-half ounce of silver to the unit of lead; (2) the pyrite carries as high as $10 a ton in gold; and (3) the arsenopyrite carries gold in amounts varying up to 135 ounces a ton of pure mineral. The arsenopyrite in particular, therefore, is sufficiently auriferous to provide a possible source of gold for the placer deposits.

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[1]. 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. It is possible that very much 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.

[1]Macpherson, J. A.: "Cariboo Placers and Lodes"; Min. and Eng. Rec., vol. XXIV, p. 128 (1919).

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 which 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 had the opportunity of taking on 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.

[1]Maclaren, J. M.: "Gold, Its Geological Occurrence and Geographical Distribution"; London, 1908, p.1).

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 which 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,[1] Brokaw,[2] 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.[3] 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 analyses 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,[4] the carbonates, calcite, siderite, rhodochrosite, rapidly precipitate gold from chloride solutions, and Emmons[5] states that "siderite is particularly efficient probably because in acid abundant ferrous sulphate forms."

The gold is found under conditions which suggest that both siderite and pyrite were its precipitants. Several pieces of vein gold (and placer

[1]Emmons, W. H.: "The Enrichment of Ore Deposits"; U.S. Geol. Surv. Bull. 625, pp. 305-308 (1917).
[2]Brokaw, A. D.: "The Solution of Gold in the Surface Alterations of Ore Bodies"; Jour. Geol., vol. 18, pp. 321-326 (1910).
[3]Emmons, W. H.: Op. cit., pp. 308-310.
[4]Brokaw, A. D.: "The Secondary Precipitation of Gold in Ore Bodies"; Jour. Geol., vol. 21, p. 256 (1913).
[5]Emmons, W. H.: Op. cit., p. 311.

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.[1] 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 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.[2] 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

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[1]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.

[2]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).

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 which occur in the bottoms of the deep, V-shaped valleys.

RELATIONSHIP OF THE PLACER TO THE VEIN GOLD

The occurrence of large amounts of coarse, nuggety gold, gold crystals, and mammillary gold in the placers and the apparent general absence of coarse gold in the auriferous veins of Barkerville area are the main apparent difficulties in the way of accepting the view that the placer gold is detrital in origin and was derived from the oxidation of the sulphides in the veins. It is held, however, that these difficulties are overcome by a consideration of the facts set forth above and here summarized.

During the long period in Tertiary, and possibly also in late Cretaceous, time when the country was being gradually reduced to a nearly plain-like surface of erosion, oxidation of the sulphides of the quartz veins and gold enrichment in the upper, oxidized parts of the veins must have taken place on a fairly large scale.

The comparatively narrow and deep, V-shaped valleys, in which the rich placer gold has been mined, show that the old plain-like surface was later uplifted and dissected by streams. The free gold of the Tertiary bonanzas was gradually washed down into their beds and during the gravitation downward of the angular, crystal and leaf gold of the veins, the corners and edges become rounded, the sharp points and other protuberances were bent, the enclosed quartz was gradually removed, and silver was selectively leached from the peripheries of the grains. Many of the nuggets of the gravels were derived in this way.

The placer gold, as well as the vein gold, is crystalline, and in both cases there is evidence that it was formed by a process of gradual accretion from gold solutions. Masses of the gold thus deposited in the vicinity of the water-table in the veins, and only slightly modified subsequently by the action of the streams, are found in the placers. They probably owe their irregular outline to the shape of the cavities in which they were formed.

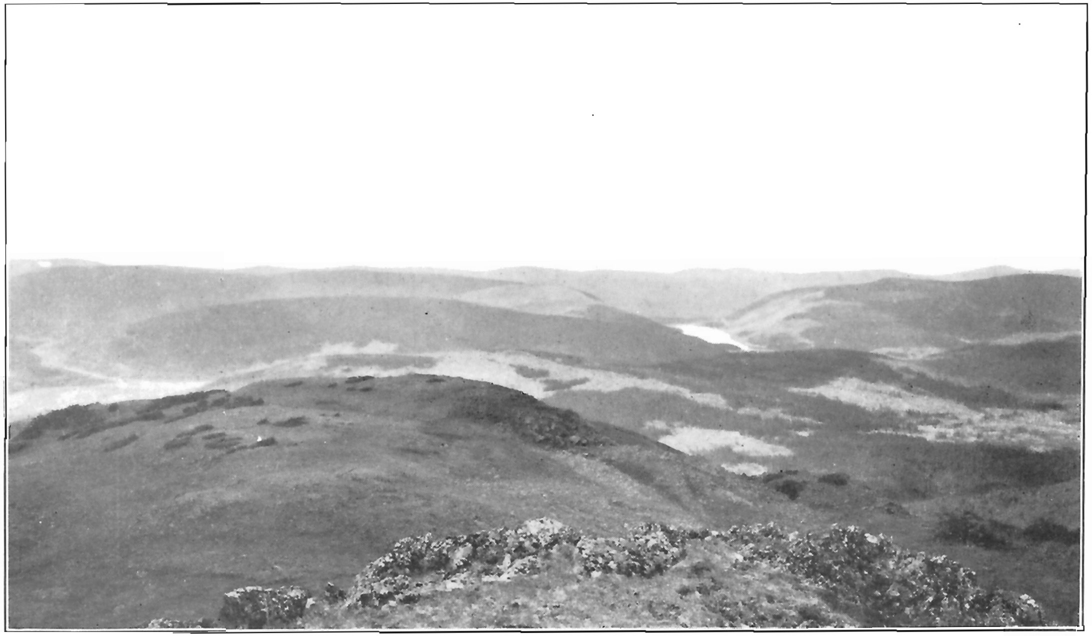
Gold crystals occur in the oxidized parts of the veins, as well as in the placers. Those found in the placers are usually somewhat worn. It is, therefore, improbable that they are formed in the gravels.

The apparent general absence of coarse gold in the exposed parts of the veins may be explained partly in one way and partly in another. From the relatively insignificant amount of lode mining, resulting in the recovery of only a few thousand dollars worth of gold, specimens of free gold of a maximum weight of about 5 ounces have been found. From the mining of about $35,000,000 of placer gold, representing the concentration from the wearing away of a great thickness of the country rock and veins, there is said to have been obtained only one or two nuggets above 30 ounces in weight. Lack of exploration of the ledges, therefore, may be partly the reason for the failure to find any but small amounts of coarse quartz gold. During the time when the country was being reduced to a plain, conditions were, probably, very favourable for gold enrichment in the upper parts of the veins. The gold thus formed and released by weathering gravitated into the old age valleys in the plain. Rejuvenation of the streams by uplift caused a further concentration in valleys, which coincided nearly with the ancient valleys. The free gold in the outcrops on the plateau represents the roots of the ancient enriched zone, the upper parts of which were removed to the streams. Most of the vein enrichments which produced coarse gold in the past have thus undergone two concentrations in the stream beds, leaving only a small part of these enrichments for exploration today. Ice erosion during Pleistocene time also removed parts of the enriched zone. It is, therefore, not be expected that the present outcrops of the veins would be as rich in free gold as the ancient outcrops were. There is every reason to suppose that, if the oxidized parts of the veins could have been examined before the plain-like surface of the region was uplifted and dissected, rich bonanzas of free gold would have been encountered.

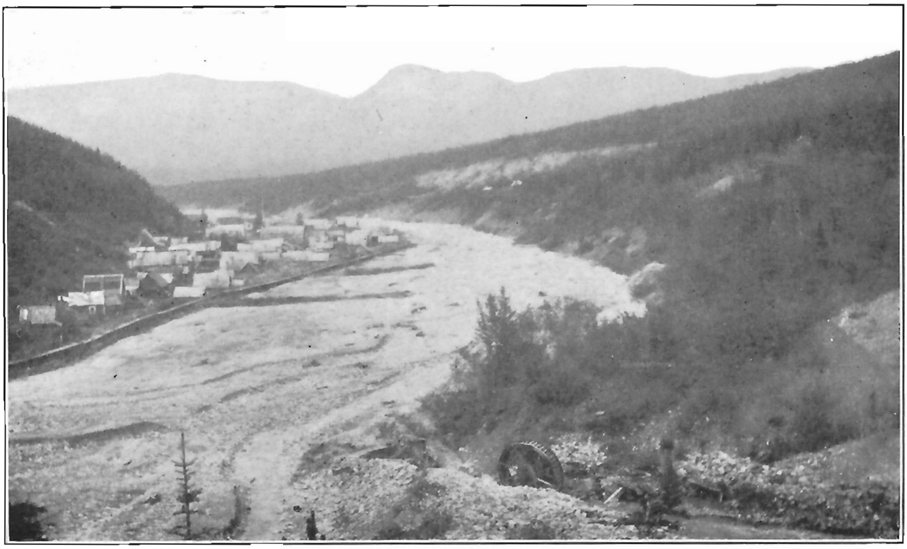
PLATE II

View east from Bald mountain showing upland and Cariboo mountains in distance.
(No. 80, Nichols, 1920.) (Page 2.)

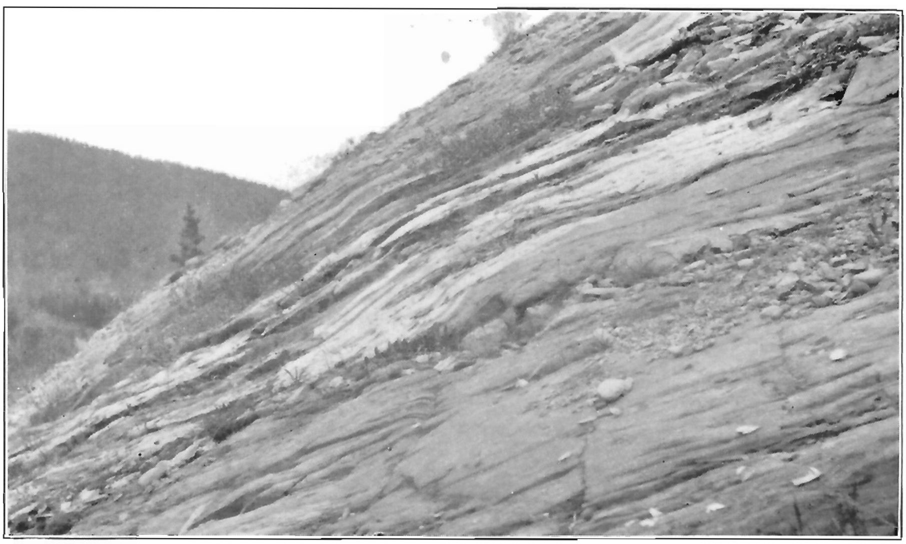
PLATE III



View west from mount Murray, showing rounded summits of Barkerville area and nearly accordant summit levels; Jack of Clubs lake in middle distance. (No. 125, Nichols, 1920.) (Page 2).



A. View down Williams creek at Barkerville.

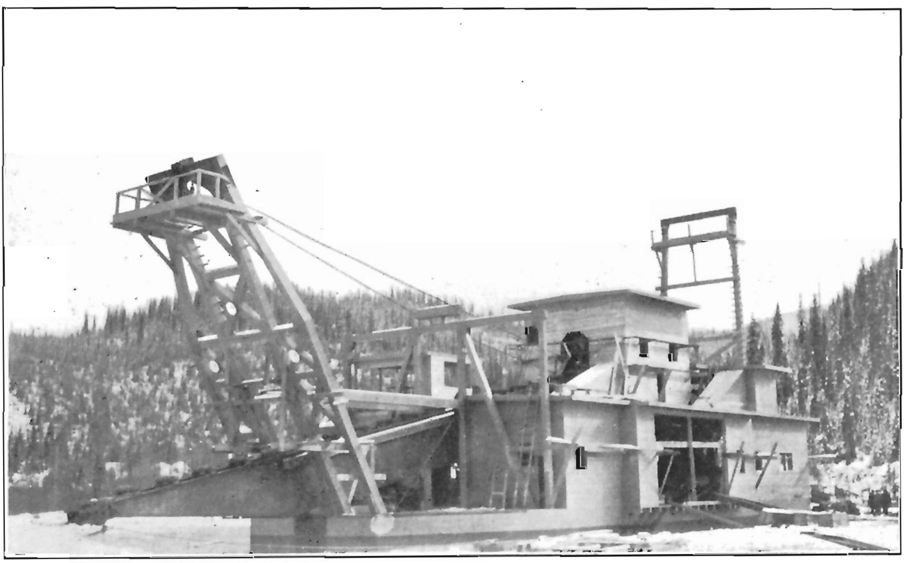


B. Glaciated rock surface on Williams creek, above canyon. (Page 26.)

A. Glacial gravels showing imbricated structure, overlain by boulder clay, New Waverly hydraulic pit, Grouse creek. (Page 28.)

B. Section of glacial drift and lignite in upper part, south bank of Lightning creek, 1½ miles above junction of Swift river. (Page 29.)

A. Glacial gravels on bedrock, Mosquito creek. (Page 118.)

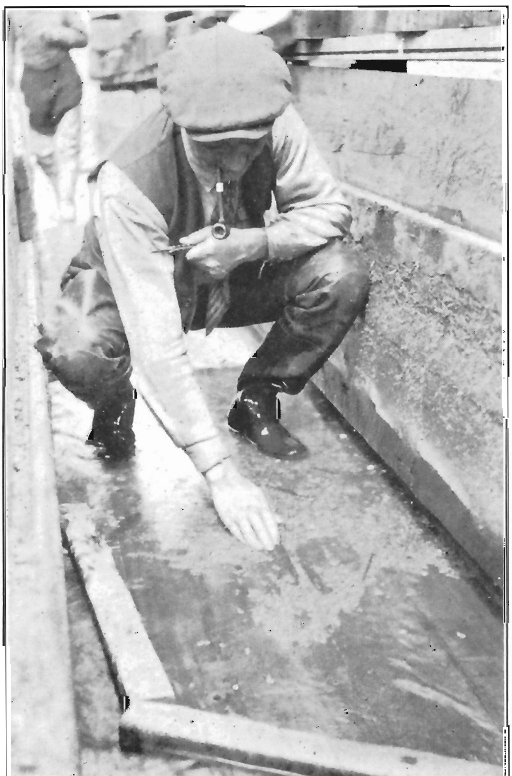


B. Gold dredge under construction by Kafue Copper Development Company, Antler creek, October, 1924. (Page 180.)

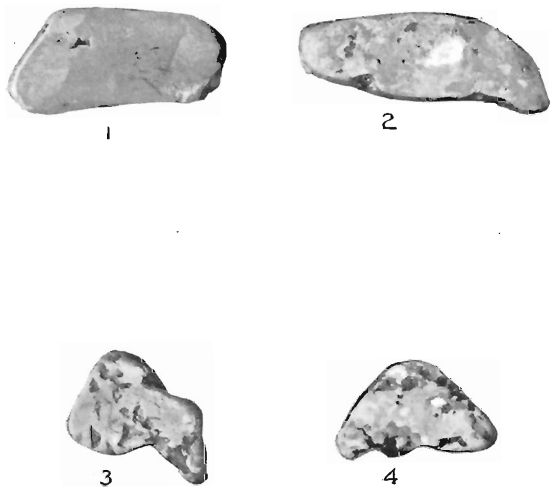
A. Hydraulicking on Lowhee creek. (Page 44.)

B. Hydraulicking with one No. 6 Monitor and ground-sluice, Lowhee creek. (Page 44.)

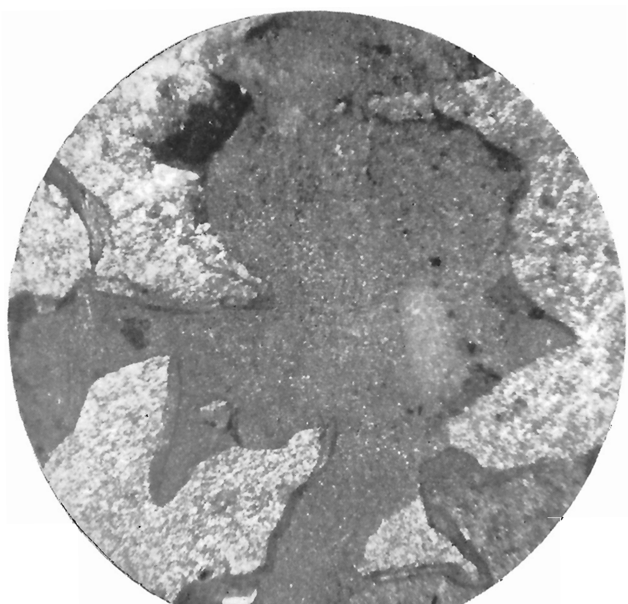
A. Hydraulicking at New Waverly pit on Grouse creek. (Page 87.)



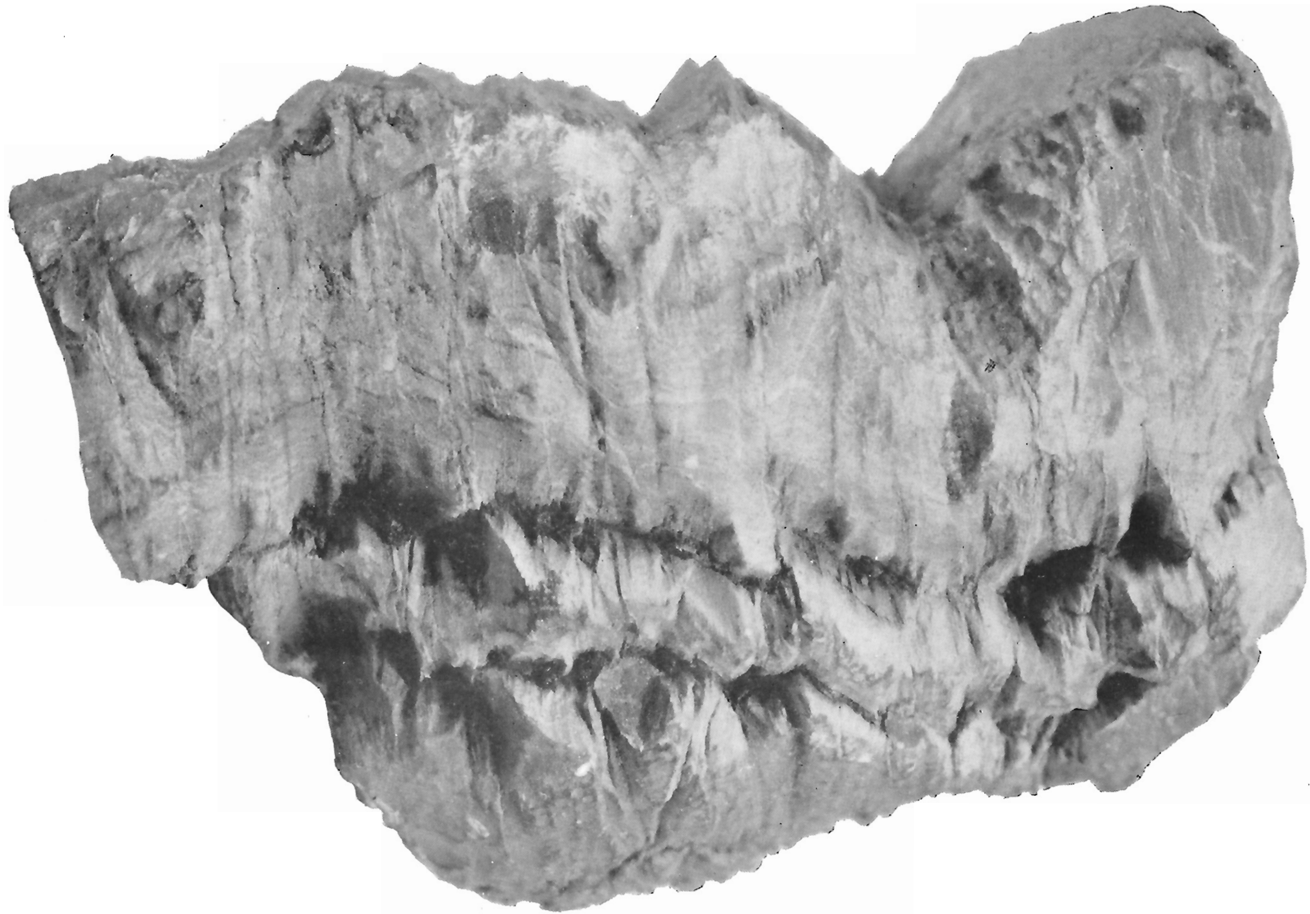
B. Gold "clean-up" of sluice boxes at Mosquito hydraulic mine. (Page 118.)



A. Polished and etched gold nuggets from Cariboo, B.C.; magnified 2 diameters. (Page 218.)



B. Polished and etched surface of gold nugget from Cariboo, B.C., showing the irregular contact of gold crystals of different fineness; magnified 128 diameters. (Page 218.)



Specimen of Barkerville limestone from Shepherd creek, showing crenulated bedding planes approximately horizontal with prominent-fracture cleavage or slicing parallel to the axial planes of the folds. ($\frac{5}{7}$ actual size). (Page 14.)

PLATE XI

Specimen of closely folded limestone of the Barkerville formation from Grouse creek. ($\frac{3}{4}$ actual size.) (Page 33.)

PLATE XII

A. Drag-folding in argillaceous quartzite of the Richfield formation, from crest of mount Agnes. The vertical side of the specimen shows the surface of slaty cleavage parallel to the axial planes of the drag-folds. White layers are quartzite; rest is argillite. ($\frac{5}{8}$ actual size.) (Page 34.)

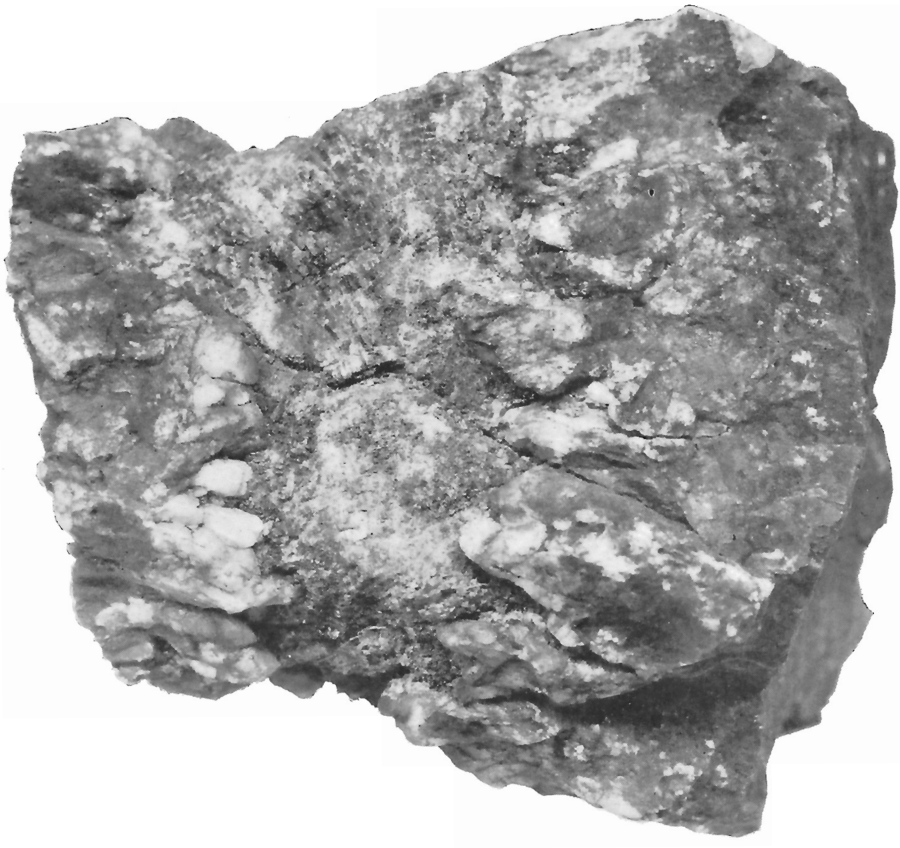
B. Quartz slate of the Richfield formation, showing bedding planes dipping downward to the left, and slaty cleavage vertical. ($\frac{5}{8}$ actual size.) (Page 34.)

C. Slate of the Pleasant Valley formation, showing folding of beds and prominent flow cleavage parallel to the axial plane of the folds. (Page 34.)

PLATE XIII

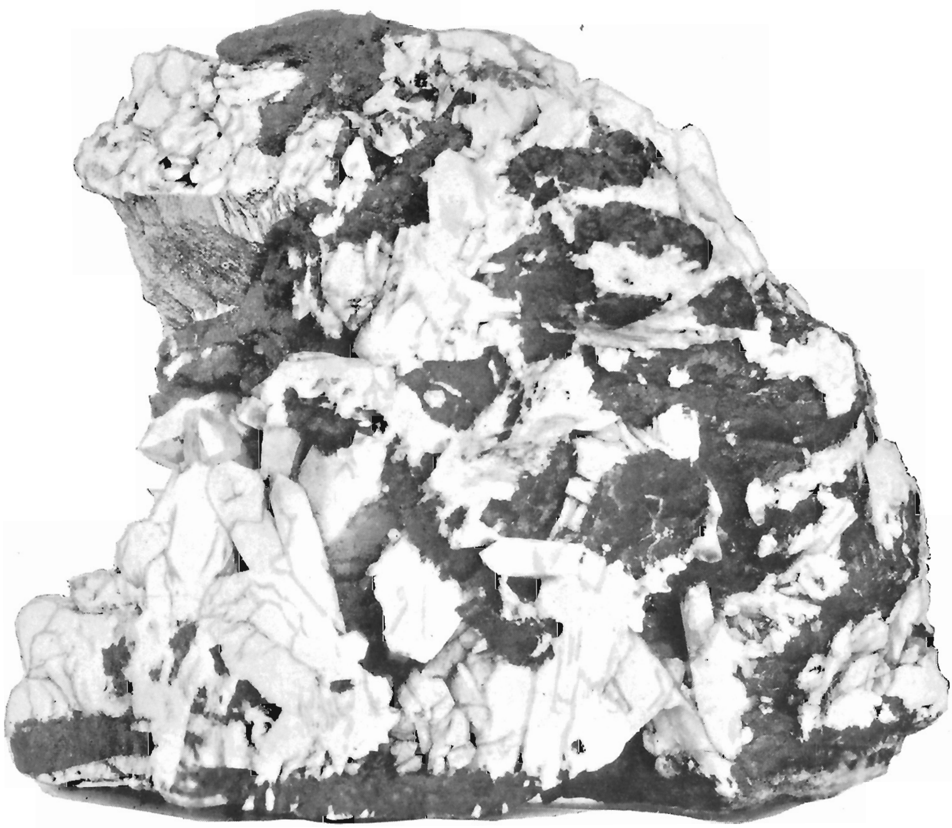
Specimen of Richfield quartzite from crest of mount Agnes, showing the character of the minor parallel folds which are typical of the Richfield formation. ($\frac{3}{4}$ actual size.) (Page 33.)

PLATE XIV



Cross-section of undeformed type of B vein, showing combs of quartz crystal rooted on the two walls, and a central filling of granitoid galena. ($\frac{2}{3}$ actual size.) (Page 190.)

PLATE XV



Cross-section of undeformed type of B vein, showing crystals rooted on walls, and interstitial siderite. Now largely altered to limonite. ($\frac{7}{8}$ actual size.) (Page 190.)

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