BRITISH COLUMBIA DEPARTMENT OF MINES
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BULLETIN No. 38

Geology of the
Antler Creek Area
Cariboo District, British Columbia

By A. Sutherland Brown

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PLATE I

View southeast up Antler Creek from Beggs Gulch toward Roundtop Mountain.

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Geology of the Antler Creek Area, Cariboo District, British Columbia

SUMMARY

1. The Antler Creek area is in east-central British Columbia about half-way between the northwesterly and southerly flowing parts of the Fraser River. The area adjoins the Roundtop Mountain-Yanks Peak area on the north.

2. The area is in a region transitional between the Interior Plateau to the west and the Cariboo Mountains to the east.

3. A mountain ice-sheet covered the entire area at least once and, although the ice must have been almost static, some movement to the southwest occurred.

4. The geology is complex and there have been a number of interpretations of the structure and stratigraphy of the Cariboo group.

5. The Cariboo group underlies the greater part of the area. Characteristic rocks of the group are phyllite, micaceous quartzite, and limestone. The group is divided into five formations, which are, from oldest to youngest, the Cunningham limestone, Yankee Belle formation of brown phyllite and less fine quartzite, Yanks Peak quartzite, Midas formation of black phyllite and metasiltstone, and the Snowshoe formation of micaceous quartzite, phyllite, and less limestone.

6. No fossils have been found in the group within the area, but just beyond it an Early Cambrian fauna has been collected from the Cunningham limestone.

7. The Cariboo group is overlain with unconformity and great structural discordance by the Slide Mountain group of Carboniferous age.

8. The Slide Mountain group is composed dominantly of conglomerate, argillite, chert, and diabasic pillow lavas and flow breccias. The group is divided into two formations—the basal Guyet formation, composed of conglomerate, flow rocks, argillite, and minor crinoidal limestone, and the Antler formation, composed of chert, argillite, and pillow lavas.

9. The chert of the Antler formation appears to have originated by more than one process and the silica originated from more than one source.

10. Small acid dykes, the Proserpine dykes, cut the Cariboo group but not the Slide Mountain group. Basic intrusive rocks, the Mount Murray intrusions, cut both groups but are rare in the Cariboo group except adjacent to the Slide Mountain group. Sills in the latter group are composed of spilitic diabase, which is related spatially, texturally, and chemically, and hence probably also in age and origin, to the flow rocks of the group.

11. A great difference in manner and intensity of folding of Cariboo and Slide Mountain groups exists.

12. The Cariboo group has been closely compressed into northwesterly trending complex folds which are overturned toward the southwest in the Antler Creek area. A regional secondary foliation is developed in the Cariboo group essentially parallel with axial planes. Component grains have been flattened parallel to the schistosity.

13. Fold structures of the Wells mining camp are asymmetrical and complex and cannot be mapped without interpretation.

14. The Slide Mountain group has been folded into simple, upright, and open structures parallel to folds in the Cariboo group. The rocks are neither schistose nor greatly deformed.

15. Folds in both groups plunge at small angles to the northwest.

16. Major faults all strike within the northeast quadrant; most strike northward, but a few strike eastward. Most of the northerly faults are essentially normal faults that have some strike-slip, but others are essentially transcurrent. Faults disrupt both groups by similar amounts.

17. Reconnaissance beyond the map-area has shown:—

(*a*) The stratigraphy is similar to that of the map-area but is augmented by the Kaza group of latest Precambrian age.

(*b*) At isolated localities, Early Cambrian trilobites, archæocyathids, and algæ can be found in the Cunningham limestone.

(*c*) The regional structure culminates northeast of the map-area in a broad anticlinorial arch of Kaza group which is flanked on the southwest by a descending series of tightly compressed folds of some complexity.

(*d*) The direction of overturning of folds reverses abruptly just southwest of the map-area.

18. The region was most intensely deformed prior to the Carboniferous, possibly in the Ordovician or Silurian.

19. The Antler Creek area was an important source of placer gold and is an important source of lode gold. Current yearly lode-gold production is greater than 1½ million dollars.

20. The lode deposits are all gold-bearing pyritic quartz veins and bedded replacements within the Cariboo group.

21. Quartz veins are oriented in a systematic manner and can be classified as follows:—

Type	Strike	Dip
Transverse veins	North 30°–55° east	70° southeast to 70° northwest.
Diagonal veins	North 70°–90° east	Steeply southeast.
Northerly veins	North-north 20° east	45°–80° east.
Strike veins	North 40°–60° west	Steeply southwest to 60° northeast.

22. Ideally, transverse veins fill the AC joints, diagonal veins the minor easterly faults, and northerly veins the northerly faults. These veins are small individually but occur in clusters that branch and ramify from one orientation to another along both strike and dip. The vein clusters are concentrated along the pre-vein northerly faults and are commonly restricted as a rule to one rock type, which is most commonly micaceous quartzite.

23. Strike veins are essentially parallel to the regional foliation. They contrast with the other types of veins in a number of respects, including their large size, common barrenness, and lack of relation to northerly faults.

24. Replacement deposits are mostly found in the Baker limestone beds of the Snowshoe formation. They consist of massive fine-grained pyrite which has entirely or selectively replaced limestone or rarely phyllite. The orebodies are pencil-shaped at fold crests or tabular on planar limbs.

25. A relation exists between northerly faults, veins, and replacement deposits. Lodes of both types may be said to occur within " ore-making range " of northerly faults. The northerly faults appear to have been the main conduits and the transverse fractures the main distributary system of the gold-pyrite mineralization. There is some evidence that the gold-pyrite mineralization was later than the formation of veins and in some instances only indirectly related to them.

26. The age of the gold-pyrite mineralization is probably Mesozoic or Early Tertiary.

27. The principal and only producing lode mines are the Cariboo Gold Quartz and Island Mountain mines of the Wells camp.

CHAPTER I.—INTRODUCTION

Work was started in the Antler Creek area as a continuation of a project initiated at Yanks Peak by Stuart S. Holland. That project started as an investigation of lode and placer occurrences in the Cariboo District but developed into an entirely new interpretation of the structure and stratigraphy. Work in the Antler Creek area extends the mapping at Yanks Peak and Roundtop Mountain to the gold-mining camp of Wells. Conclusions of regional importance have led to the work being continued to the east and southeast, and a preliminary account of this regional work is given in this bulletin.

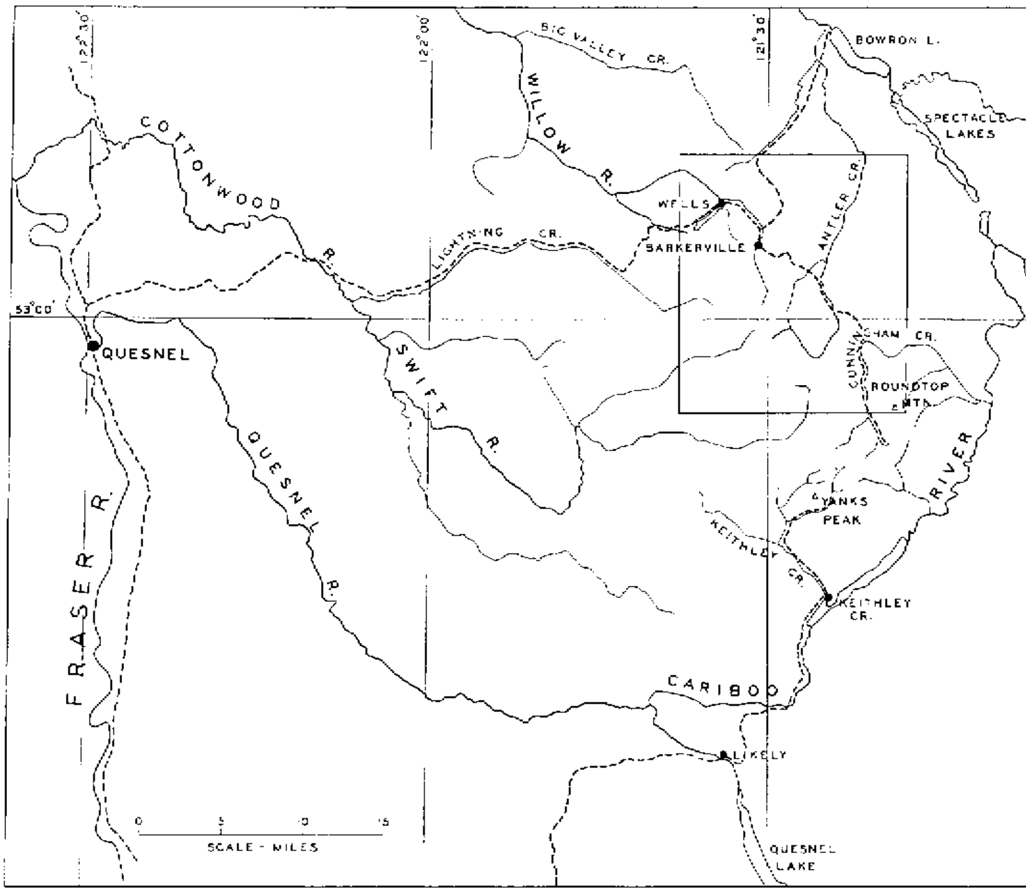

Figure 1. Index map showing location of Antler Creek Area.

LOCATION AND ACCESS

The Antler Creek map-area (*see* Fig. 1) is situated in east central British Columbia about half-way between the northwesterly and southerly flowing parts of the Fraser River. The 53rd parallel and the 121° 30′ meridian pass through the centre of the area. The mapped area includes approximately 130 square miles in a polygon whose long dimension is parallel to the northwesterly structural trend of the Cordillera.

The area has a humid continental climate, with a cool short summer. This climate supports a dense coniferous forest with a considerable amount of undergrowth extending from the valleys to within a few hundred feet of timberline (about 6,200 feet). Much of the upland is just below timberline and so is park-like with sparse trees and little undergrowth. Rock outcrop is not abundant on the upland except in small cirques. Below timberline, outcrop is rare except along creeks that are actively down-cutting and in hydraulic pits.

The Antler Creek area includes the town of Wells and the village of Barkerville. Wells is 51 miles by gravel road east of Quesnel, and Barkerville is an additional 4 miles. Dirt roads lead from Barkerville southeast to the Cariboo-Hudson mine and east to Bowron Lake; these and several minor roads provide access within the area.

The Antler Creek area is an important source of lode and placer gold. The Cariboo Gold Quartz and Island Mountain lode-gold mines at Wells have produced more than 32 million dollars in bullion since 1932. Placer-mining has probably produced an equivalent or greater amount. Current annual lode-gold production has a value greater than 1½ million dollars, but current placer production is but a small fraction of this figure.

PREVIOUS WORK

The area surrounding Barkerville has been the chief centre of interest to placer-miners in the Cariboo since the discovery of gold on Antler Creek in the winter of 1860–61. Following the discovery, production rose sharply to a peak in 1863 of about 4 million dollars and by 1874, the date of the earliest detailed records, fully a third or a half of the placer gold produced to date had been mined.

As the revenue from placer mines dropped, interest turned in part to the numerous quartz veins of the region. The first systematic geological investigations were begun by Amos Bowman in 1885 to aid such development (*see* Bowman, 1889, 1895). From two seasons' field work he produced topographic and geological maps, on a scale of 2 miles to the inch, which covered more than a degree square from Bowron (Bear) Lake in the north to Quesnel Lake in the south, and, in addition, he produced detailed maps of the richer placer creeks. Although later investigations have been made of parts of Bowman's map-area, much of it has not yet been re-examined.

W. L. Uglow (*see* Johnston and Uglow, 1926) mapped the Barkerville area in 1922 at 1 mile to the inch and studied the lode deposits; W. A. Johnston studied the placer deposits from 1921 to 1924.

G. Hanson (1934, 1935) mapped the Willow River area in 1933 at 1 mile to the inch, and in 1934 mapped a narrow zone, the "Barkerville Gold Belt," between Island Mountain and Grouse Creek at 1,000 feet to the inch.

N. F. G. Davis (1937) continued mapping of the "Barkerville Gold Belt" on Island Mountain at 1,000 feet to the inch.

A. H. Lang (1938) mapped the Little River and Keithley Creek areas in 1935–37 at 1 mile to the inch.

The present map-area includes part of all of the foregoing areas.

P. C. Benedict (1945) and A. C. Skerl (1948b), in papers on Island Mountain and Cariboo Gold Quartz mines, respectively, made important contributions to knowledge of the region.

Stuart S. Holland (1954) mapped the area from Yanks Peak to Roundtop Mountain in 1948–51 on a scale of 1,200 feet to the inch.

FIELD WORK AND ACKNOWLEDGMENTS

This report is based on the following field work: A three-week preliminary examination of the area in September, 1951, four months in 1952, and three months in 1953. The earlier part of the 1951 season was spent mapping in the Roundtop Mountain area under Dr. Holland's supervision. A month each in 1954 and 1955 were spent in reconnaissance southeast and east of the Antler Creek area.

Geology was mapped directly on low-level vertical aerial photographs and transferred to a plot prepared at a scale of 1,000 feet to 1 inch by the Air Surveys Division of the British Columbia Department of Lands and Forests. After the geological mapping was completed, a topographic map was prepared at 2 inches to 1 mile by the Air Surveys Division, with drainage and culture taken from aerial photographs and contours from previous maps. The geology was transferred to this map, which is accurate as to drainage and moderately accurate as to topography.

Part of the laboratory work was done at the Department of Geology of Princeton University, and much helpful advice was received from members of the faculty, particularly Professors B. F. Howell, J. C. Maxwell, F. B. Van Houton, and E. F. Roots. Professor Howell, and Professor V. J. Okulitch of the University of British Columbia, examined fossils collected in the area and adjacent regions. Capable assistance in the field was rendered by G. E. Apps in 1951, G. A. Kezin in 1952, Y. Kawase in 1953, E. Burton in 1954, and by W. S. Hopkins and Y. Kamachi in 1955. The mining men, prospectors, and residents of the area were generous in their help, especially W. E. Thompson, J. J. Gunn, E. S. Dowsett, and the management and staffs of the Cariboo Gold Quartz and Island Mountain mines.

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CHAPTER II.—PHYSICAL FEATURES AND GLACIATION

PHYSIOGRAPHY

The map-area is in a region transitional between the Interior Plateau to the west and the Cariboo Mountains to the east. The Interior Plateau is here a rolling upland surface at an altitude of approximately 6,000 feet and with a regional dip of about 75 feet per mile to the southwest. This surface bevels all pre-Tertiary formations. In the map-area the undulations of the upland surface are related to lithology, the highest areas being underlain by quartzite, conglomerate, chert, or diabase, and most of the lower hills by phyllites or limestone. The surface is moderately well dissected, with a local relief of about 2,000 feet. The Cariboo Mountains proper seem to represent the complete and deep dissection of this surface to a stage at which local relief is as great as 6,000 feet. The limits of the Cariboo Mountains have not been clearly drawn, but in the vicinity of the map-area the boundary should be placed along the trench occupied by Bowron River, Spectacle Lakes, and Matthew River. Plates III (A) and (B), which are taken looking east and west respectively on the same flight line, show the strong contrast in topography. Actually, the dissection, relief, and maximum elevations all increase from the Interior Plateau near Quesnel (Dragon Mountain) to the Cariboo Mountains. This may be evidence of a relative upwarping of the surface in the east.

Drainage

The map-area is drained by tributaries of four master streams—the Quesnel and Cottonwood Rivers, which empty into the Fraser River near Quesnel, and the Willow and Bowron Rivers, which empty about 100 miles farther north at the big bend of the Fraser River (*see* Fig. 1). The main streams within the area are Cunningham Creek of the Quesnel River system, Antler Creek of the Bowron River system, and the Willow River.

The stream pattern is markedly influenced by the northwesterly trend of the formations and by the north to northeasterly trend of major faults and joints. The large streams follow these directions and have cut the upland area into isolated blocks, on some of which the minor streams have a radial pattern that seems little influenced by structural control, as on Island Mountain.

Valley slopes are mostly gentle and uniform but are interrupted on Summit, Little Valley, Pleasant Valley, lower Antler Creeks, and possibly in China Pass by benches at approximately 4,400 feet elevation. These benches are graded in the present direction of flow of Antler Creek, and may represent an ancestral stream which probably passed to the southeast of both Blare Mountain and the next hill to the east, and then to the present Spectacle Lakes valley (*see* Plate III (B)).

Many tributaries are graded to a level above the present major streams. Small creeks such as Beggs, Coulter, Stevens, California, Mink, and Lowhee have normal longitudinal profiles except near their mouths, where they cascade through small steep canyons to meet the larger streams (*see* Frontispiece). Some disparities of grade may possibly be the result of over-deepening of the major stream by valley glaciers, but this is not the general explanation because most valleys have a V-shape and interlocking spurs.

The present drainage is incised well below the 4,400-foot benches and the pre-Pleistocene grades. Many streams have small rock-cut canyons which antedate the end of glaciation because they are partly filled with till, which commonly overlies cemented gravels of possibly Tertiary age. Drift and alluvium fill the larger valleys to just below the 4,000-foot contour, except where they have been re-excavated; for example, lower Antler Creek, lower Cunningham Creek, and Summit Creek.

The rejuvenation that caused the canyons probably brought about several stream captures. Drilling on Sawmill Flat showed that, although Sawflat Creek now has a gradient of 0.75 per cent to the north, bedrock has a gradient of 1.6 per cent to the south (*Minister of Mines, B.C.,* Ann. Rept., 1948, p. 176), and, therefore, the southerly flowing part of Antler Creek originally belonged to the Swift River. The northerly flowing part of Cunningham Creek probably at one time drained by way of Cunningham Pass into Antler Creek. There is a definite knick point in the longitudinal profile of Cunningham Creek at Cunningham Pass, below which the gradient is 2.5 per cent to within 1 mile of the Cariboo River, and above which the gradient is considerably less for over 2 miles. Furthermore, Cunningham Pass Creek is a misfit for the size of the valley. Therefore, it seems likely that although Antler Creek gained the upper part of the Swift River, it lost what is now the upper part of Cunningham Creek. Both these cases of piracy could be pre-Pleistocene. Changes directly related to glaciation are described below.

GLACIATION

The glacial history of the region is not well known beyond the fact that a mountain ice-sheet covered the entire area at least once, and, although the ice must have been almost static, some movement occurred to the southwest. Larger movements undoubtedly occurred beyond the map-area in deep valleys such as those of the Cariboo River and Quesnel Lake, down which the ice appears to have moved to the southwest and then swung round to the northwest along the Quesnel River and out into the "lowlands." The glacial history ended, as it may have begun, with a stage of valley glaciers.

Glaciation has modified the topography of the area only slightly. Although weathered material has been completely removed by ice from both uplands and valleys, there has been little sculpturing of topography, except for the formation of small cirques on the higher hills and slight faceting of some spurs. Small cirques have been fretted out of the northeastern side of the rounded hills. They thus seem to have resulted chiefly from the late valley glaciation. Some of them still contain small amounts of névé at the end of summer. Bald Mountain and Mounts Agnes, Burdett, Guyet, and Murray have the most pronounced cirques. A slight appearance of U-shape in some of the larger valleys is commonly the result of fill and not of scour. The presence of glacial groovings and polish in V-shaped valleys such as those of Cunningham Creek and Williams Creek above Barkerville indicates that they were occupied by moving ice but little modified by it. Therefore, as there has been only minor deepening or widening of the main valleys, it is probable that the area was not one in which major ice movement occurred.

The direction of ice flow probably varied at different times in glacial history, because movement must have been channelled by main valleys during the early and late stages of the ice-sheet and during the periods of valley glaciation. Just as river systems radiate from the map-area now, ice flow probably radiated from it at these stages. However, during the maximum stage of ice-sheet development, ice moved bodily across the area to the southwest.

On Williams Creek, near Walker Gulch, groovings indicate a southwesterly ice movement up Williams Creek, but some chatter marks and striations cutting across the main groovings at a small angle indicate a northeasterly movement down the valley that was probably that of a valley glacier. Some *roches moutonnées* in Cunningham Pass indicate southerly flowing ice. No striations were found above an elevation of 5,000 feet, but a few erratic boulders occur near the top (6,500 feet) of Mount Murray and Mount Greenberry. These boulders are formed of greenish-white quartzite that is unlike any exposed in the map-area but resembles those of the Kaza group, which is exposed in the Cariboo Mountains to the northeast. On Williams Creek near Walker Gulch several 10-foot-diameter erratic boulders resemble the cobble conglomerate of the Guyet formation. These boulders could have come from either north or east, but, because of the striations on adjacent bedrock, they probably indicate a southerly movement of ice. One other indication of the direction of ice flow is a southerly trending esker near Pleasant Valley.

Glacial drift mantles the lower slopes and, together with stratified sands and silts, fills the valleys to about the 4,000-foot contour. The uplands are covered by little or no drift. In the main valleys a maximum depth of 287 feet of fill was determined by drilling at the confluence of Nelson and Slough Creeks just west of the map-area. The deepest bore-hole showed, from bedrock up, 22 feet of gravel, 30 feet of till, 150 feet of silts and sands, 15 feet of gravel, 70 feet of till. Other main valleys have similar, if smaller, thicknesses of fill. Small terminal moraines on top of the valley fill, such as those at the mouth of Jack of Clubs Creek, on Slough Creek, and elsewhere, also indicate a final valley glacier stage. Most creeks flowing into the main valleys expose relatively thick sections of glacial and fluvioglacial sediments. In a typical section exposed by hydraulic mining on lower Grouse Creek, 20 feet of sands and 30 feet of pebble and cobble gravels are overlain by 12 to 20 feet of till. The depth of drift between the subsidiary creeks is a fraction of the foregoing section but may be comparable to the thickness of till.

Glaciation has caused some changes in the drainage of the area, of which the most notable example is that of the Willow River. The valleys of the Willow River and of Jack of Clubs Lake and Slough Creek are comparable in size, and it seems probable that the Willow River has flowed in both channels. The gradient of bedrock indicates that the immediately pre-Pleistocene flow was westward through the valley of Jack of Clubs and Slough Creek. The depth to bedrock increases uniformly from about 100 feet at the meadows near Wells to 287 feet at the junction of Nelsons (Nelson) and Slough Creeks, whereas the maximum depth at the mouth of Red Gulch is only 68 feet (*Minister of Mines, B.C.*, Ann. Rept., 1951, p. 203). Alluvium and drift fill both valleys to essentially the same level, so the change to the present drainage route probably resulted from morainal or ice damming.

Drainage was undoubtedly much disrupted at the times of encroachment and dissolution of the ice-sheet. The confused stream pattern along the lower southwest slopes of Mount Murray and Mount Greenberry, drained by Alex Allan, Jubilee, and Yellowhawk Creeks, may have resulted from incision by melt-water streams which flowed laterally along a changing body of ice. Lateral drainage is also indicated by two small deep gullies on the lower southeast slopes of Bald Mountain. Melt-water probably flowed from a valley glacier in Racetrack Flat, north across the divide, and down Grouse Creek.

No good evidence is known of two separate periods of glaciation in the region. The common occurrence of sand and gravel between two till sheets may only indicate a minor retreat and readvance of ice.

Johnston and Uglow (1926, p. 30) found a few fossil teeth of *Elephas primigenius* Blumenbach that indicate the stratified deposits in the valleys of the area are of Pleistocene age. Parts of a prehistoric elephant tusk were found by Mr. Dannhauer, of Barkerville, on the tailings of the Kumhila dredge on Williams Creek in 1954, but they were in a condition that made specific identification impossible.

CHAPTER III.—GENERAL GEOLOGY

INTRODUCTION

The region including and immediately contiguous to the Antler Creek area has been repeatedly examined by geologists. It has probably received more attention than any comparable area in British Columbia, and yet the areas surrounding it have either been ignored or have received cursory reconnaissance. Undoubtedly the main reason for this state is that attention has been focused on localities containing important placer- and lode-gold deposits. If the geology were simple the geological problems would have been solved by the first investigation, but the present (or fifth) examination does not exhaust the possibilities of the area. The answers to some remaining problems should be looked for beyond the area to which mapping was previously restricted. The writer is currently mapping in adjacent areas, and some of the preliminary results are mentioned in this report (*see* Chapter V). The present study, initiated by Holland, has the advantage not only of all previous work, but also of more time spent in the field and more detailed mapping.

The geology of the area is not simple. Multiple deformation has rendered most of the rocks schistose and tightly compressed in complex repetitive folds. A subtlety of rock differences, an obscurity of bedding, facies changes in some formations, and a variation in intensity of hydrothermal alterations all combine to make a complex relationship which poor rock exposure further compounds. It is therefore not surprising that a variety of interpretations has resulted from past work.

The northeastern Cariboo District is underlain by four major groups of rocks, of which only two outcrop within the map-area. All groups are compressed into northwesterly trending folds of greater or lesser complexity. The oldest rocks—schists, schistose greywackes, and micaceous quartzites—form the Kaza group (Latest Precambrian), which outcrops east of the map-area. The Kaza group is a newly defined unit and is discussed in Chapter V. The Cariboo group (Early Cambrian and Later) comprises phyllites, limestones, and micaceous quartzites and conformably overlies the Kaza group. Most of the Antler Creek area is underlain by the Cariboo group. It is in this group that complexities and obscurities abound, and efforts to explain its relations have led to a variety of interpretations. The Slide Mountain group (Carboniferous) comprises cherts, argillites, basic pillow lavas, and conglomerates. It overlies the Cariboo group with great unconformity and is much less deformed and metamorphosed. The Slide Mountain group fills a narrow trough, of which the southwestern part fringes the map-area. The Quesnel River group (Jurassic and Later?) comprises shales and andesitic volcanic rocks. It is poorly exposed beyond a contact about 10 miles southwest of the map-area.

SUMMARY OF INTERPRETATIONS

The interpretations of the geology of the area are reviewed in historical sequence. The main differences in interpretation are concerned with the stratigraphy and structure of the rocks now called the Cariboo group.

Bowman (1889) achieved much in his hasty reconnaissance of a large area. His cross-section is shown in Figure 4A and his stratigraphic column in Table I. He recognized and mapped the major rock divisions, and boundaries between these large units have not been greatly changed by succeeding workers. The Cariboo group of the present map-area is the equivalent of Bowman's "Quesnel Lake Crystalline Series" and "Cariboo Schists." Gneissic granitic rocks near Quesnel Lake and massive quartzites were included in the "Quesnel Lake Crystalline Series," which was judged to be Archæan because of its similarity to Archæan rocks in eastern Canada. He estimated the "Cariboo Schists" to be 5,000 to 8,000 feet thick and assumed that they were much duplicated. The "Quesnel Lake Crystalline Series" is treated in his report with the "Cariboo Schists," but, judging by his section, it was not included in his estimate of thickness. The

" Cariboo Schists," being metamorphosed more than the Carboniferous " Bear River Beds " and less than the "Archæan " rocks, were thought to " constitute some part of the *Lower Palæozoic—perhaps even pre-Palæozoic, system " (Bowman, 1889, p. 23).*

Bowman's cross-section is highly interpretive but shows large, tight, overturned, and asymmetric folds. Bowman's and Holland's cross-sections (*see* Fig. 4) are drawn through essentially the same positions, but they show little similarity, except the average dip of beds and some correspondence between lithologies.

Johnston and Uglow (1926) mapped the Barkerville area and divided the " Cariboo Series " into three formations, which, in ascending order, were the Richfield formation, which was dominantly quartzose; the Barkerville formation, which was dominantly limy; and the Pleasant Valley formation, which was dominantly argillaceous. Their stratigraphic column is shown in Table I and their cross-section in Figure 4B. The " Cariboo Series " included not only the quartzites which Bowman named part of the " Quesnel Lake Crystalline Series," but also massive limestone which he included with near-by Carboniferous strata. They stated that, although the only direct evidence of the age of the " Cariboo Series " was that it was pre-Mississippian, the considerable metamorphism and the resemblance to Beltian rocks possibly indicated a " Beltian age."

Table 1.—Comparison of Geological Sections Proposed for the Wells-Barkerville Area[1]

Era	Bowman (1889) Unit (Feet)	Bowman (1889) Lithology	Johnston and Uglow (1926) Unit (Feet)	Johnston and Uglow (1926) Lithology	Hanson (1935) Unit (Feet)	Hanson (1935) Lithology	Holland (1954) Unit (Feet)	Holland (1954) Lithology
Mesozoic.	Quesnel River beds.	Argillite, agglomerate.	Mount Murray intrusions.	Diabase, gabbro, diorite.				
Upper Palæozoic.	Bear River beds.	Limestone, cherty quartzite, volcanics.	Slide Mountain series. Antler formation 3,500+.	Thinly bedded vari-coloured chert inter-bedded with grey-green shale.				
			Waverly formation 2,000±.	Basic volcanic flows and breccias.				
			Greenberry formation 400.	Crinoidal limestone.				
			Guyet formation, 900.	Basal conglomerate.				
Lower Palæozoic and (or) Proterozoic.	Cariboo schists 5,000–8,000.	Schists of greatly varied character.	Proserpine intrusives.	Quartz porphyry, felsite.				
			Cariboo series. Pleasant Valley formation 5,000+.	Slate, phyllite, sericite schist, schistose volcanic breccia.			Cariboo group. Snowshoe formation 500+.	Grey to brown sericitic quartzite, granule to pebble conglomerate, sericite and chlorite schist, limestone.
			Barkerville formation 2,500.	Limestone, quartzite, micaceous quartzite, slate, sericite schist.			Midas formation 500.	Black phyllite, slate, siltstone; limestone.
			Richfield formation 8,000+.	Quartzite, quartz-slate, sericite schist, fine-grained conglomerate, black carbonaceous slate.	Baker member 1,000–1,500.	Fissile and non-fissile calcareous quartzite, limestone.	Yanks Peak quartzite 50–200.	Grey to white, massive fine grained quartzite.
					Rainbow member 500–600.	Fissile and non-fissile interbedded argillite and quartzite, limestone.		
					B.C. member 800—.	Black argillite.	Yankee Belle formation 500–900.	Light grey to brown phyllite with interbedded quartzite, chlorite schist.
					Lowhee member 2,000±.	Fissile and non fissile quartzite, limestone.		
					Basal member 1,000–2,500.	Black argillite.	Cunningham limestone 400+.	Grey limestone.
					Undivided Richfield formation.			
Archæan.	Quesnel Lake crystalline series.	Granitoid rocks, quartzites.						

[1] NOTE.—No correlation is intended except the largest units.

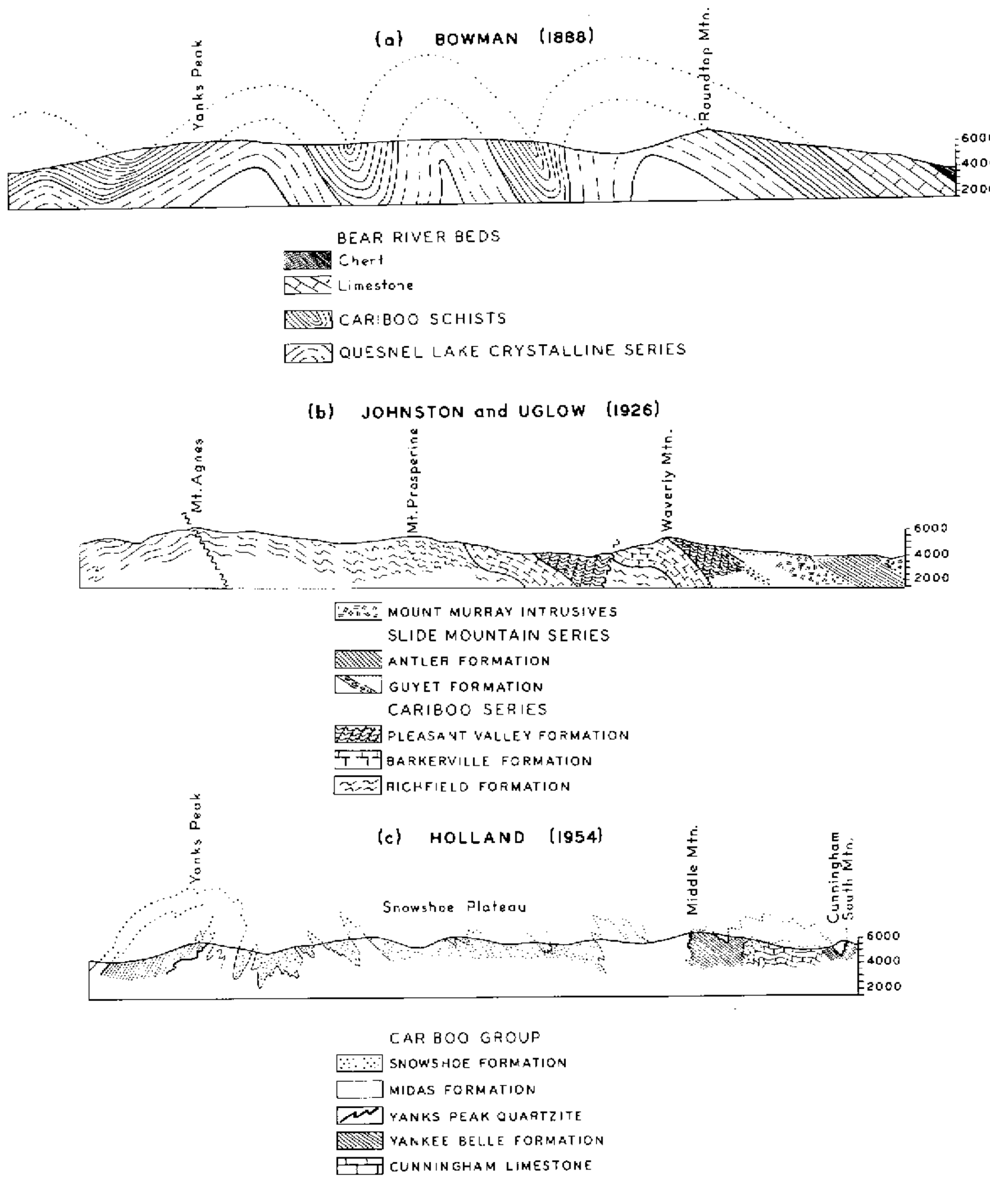


Figure 4

DIAGRAMMATIC CROSS-SECTIONS

Scale 2 0 2 4 6 Miles

Johnston and Uglow interpreted the structure (*see* Fig. 4B) as a broad, open, anticlinorium whose form was controlled by competent members such as limestones of the Barkerville formation and quartzites of the Richfield formation. The incompetent strata were in some instances intensely dragfolded but with small amplitudes. A major fault parallel to the strike of the strata was postulated to explain an apparent duplication in lithology. Figure 4B is drawn through approximately the same position as Section C-C[1] of Figure 9.

Hanson (1934, 1935) accepted the succession of Johnston and Uglow, and subdivided the " upper part of the Richfield formation " between Island Mountain and Grouse Creek into five members (*see* Table I). All members were believed to face northeastward on the northeastern limb of a regional anticline. An alternative structural situation, involving a large plunging dragfold, was postulated to account for the distribution of rock types, but was rejected because " the dips do not support it " (1935, pp. 7–8). Evidently, tight overturned folds were not recognized.

Lang (1938) accepted Johnston and Uglow's structural interpretation. Lang was unable to map Hanson's members southeast of Grouse Creek and, although he could subdivide the Richfield formation near Roundtop Mountain, he found that these members had little continuity. He recognized Lower Cambrian strata on Kimball Creek but did not include them with the Cariboo series, with which he reported they were completely conformable.

A radical structural interpretation was presented by Benedict (1945) when he showed that in the Island Mountain mine there had been two periods of folding—an early overturned isoclinal folding followed by a milder warping with vertical axial planes. He mapped a large plunging dragfold that indicated an anticline to the northeast, and thus concluded that Hanson's Rainbow and Baker members were overturned. Benedict's work and Skerl's (1948b) were limited to the Island Mountain and Cariboo Gold Quartz mines, respectively, but had important regional implications; the concept of open folding had to give way before such tangible evidence of overturned isoclinal folds.

Present Interpretation

Holland (1954) attempted to reconcile the inconsistencies of previous work by mapping at 400 feet to the inch in the Yanks Peak-Roundtop Mountain area where outcrop is relatively abundant. The present writer has extended Holland's mapping to the vicinity of Wells, and has remapped much of the Barkerville area.

The concepts of the structure and stratigraphy evolved by Holland are shown in Figure 4c and in Table I. No fossils were found in the Cariboo group within either map-area, so that the new nomenclature is based solely upon structural information and lithological similarity and sequence. A consistent lithological sequence was traced through many complicated structures.

At Yanks Peak, Holland mapped a closed dome-like anticline with a core of brown phyllites, the Yankee Belle formation, about which in ascending sequence are the distinctive Yanks Peak quartzite, black phyllites of the Midas formation, and micaceous quartzites of the Snowshoe formation. Dragfold and cleavage-bedding relations confirm the interpretation of a domed anticline. The Snowshoe formation underlies much of the area between Yanks Peak and Roundtop Mountain, and at the latter place a sequence of rock occurs similar to that at Yanks Peak and in the same order. On both mountains the Yanks Peak quartzite forms a marker which can be traced through a series of tight folds. At Rountop Mountain the thick Cunningham limestone occurs stratigraphically beneath the Yankee Belle formation in the core of the Cunningham anticlinorium.

The Yankee Belle, Yanks Peak, and Midas formations can all be mapped on the eastern limb of the Cunningham anticlinorium. Lang mapped these as Pleasant Valley formation, whereas he mapped all rocks west of the limestone as Richfield formation. Here, in an area where the evidence of dragfolding is particularly clear (*see* Holland, 1954, Fig. 1 and Plate VII), it has been demonstrated by detailed mapping that part of the Richfield and Pleasant Valley formations are identical. At the scale at which the previous investigators worked, it would seem impossible to obtain more than a generalized idea of the stratigraphy. It has become clear in the Antler Creek area that the parts mapped by Johnston and Uglow as limestone are areas where limestone is common, quartzite where quartzite is common, and argillite where argillite is common, but this rock distribution is the result of vagaries of folding.

The Cariboo group includes essentially the same rocks as the Cariboo series, but, in contrast with earlier estimates, it is thought to be a relatively thin sequence which has been much duplicated by tight overturned folding, and faulting. The name has been changed from series to group to conform with current usage because the units dealt with are rock units and the time relations are not defined. The group is divided into five formations, but there is no easily demonstrated equivalence between these and formations of the earlier nomenclature. For example, Johnston and Uglow called the massive limestone the Barkerville formation, the middle unit of the Cariboo series, and mapped it in two belts that join together southeast of Antler Creek. Mapping in the Roundtop Mountain area by Holland showed that a thick massive limestone, the Cunningham limestone, was the base of the Cariboo group as exposed in that area. The present mapping shows that the Cunningham limestone is equivalent only to the limestone of the eastern belt of the Barkerville formation, and that this eastern belt also includes many compressed synclinal troughs of Yankee Belle formation. The western belt of the Barkerville formation contains intensely folded, thin-bedded lenses of limestone which, in the aggregate, is far less abundant than are clastic rocks. This western belt is largely Snowshoe formation, the uppermost unit of the group, and on Antler Creek includes some Midas formation. Furthermore, on Antler Creek the Antler fault has placed crenulated limestone of the Snowshoe formation in juxtaposition along strike with massive ferroan dolomite of the Cunningham limestone. Johnston and Uglow did not recognize the Antler fault and equated these rocks. In order to account for the apparent splitting of the Barkerville formation into two bands, they introduced the concept of a hinged fault approximately parallel to the strike of the formations.

The Cariboo group has been greatly compressed to form tight asymmetric folds trending northwestward. Folds in the Antler Creek area are overturned toward the southwest, but just southwest of the map-area there is an axis of change of dip of axial planes beyond which folds are overturned toward the northeast (*see* Chapter V, pp. 58–59). The axis passes through the Yanks Peak area. All folds plunge at shallow angles northwestward. Almost all Cariboo rocks are schistose as a result of the intense deformation. The area has been intensively faulted. Major faults all strike between north and north 70 degrees east and generally dip steeply eastward. Many are normal faults, but the largest are northerly striking right-hand transcurrent faults. The major faults almost exactly compensate for the regional northwesterly plunge.

Table II.—Table of Formations

Era	Period or Epoch	Unit and Thickness (Feet)		Lithology
Cenozoic.	Pleistocene and Recent.			Glacial till; glacio-fluvial sand, gravel, silt; alluvium.
	Unconformable contact.			
	Tertiary(?).			Partly cemented limonitic river-bed gravels.
Unconformable contact.				
Upper Palæozoic.	Carboniferous(?) and (?)later.	Mount Murray intrusions.		Diabase and other basic sills and dykes; lamprophyre dykes.
	Intrusive contact.			
	Carboniferous.	Slide Mountain group.	Antler formation 3,000—.	Brown, grey, white, or green chert; grey argillite; basic volcanic flow and pyroclastic rocks.
			Conformable contact.	
			Guyet formation 1,125–1,500.	Grey to brown conglomerate; grey greywacke to slate; basic volcanic flow and pyroclastic rocks; light grey to white, cherty crinoidal limestone.
Unconformable contact.				
Lower Palæozoic.		Proserpine dykes.		Brown weathering acidic dykes.
	Intrusive contact.			
	Lower Cambrian and later.	Cariboo group.	Snowshoe formation 1,000+.	Grey to brown, micaceous quartzite; brown, grey, or green phyllite, metasiltstone; black to white limestone, granule conglomerate.
			Conformable or slightly unconformable contact.	
			Midas formation 1,000+.	Black to dark grey, quartzose phyllite, and metasiltstone; black to grey limestone.
			Conformable contact.	
			Yanks Peak quartzite 0-200.	Grey to white, massive medium-grained quartzite.
			Conformable with Yanks Peak or Midas formation.	
			Yankee Belle formation 300-500.	Brown phyllite, metasiltstone, fine-grained quartzite.
			Conformable contact.	
			Cunningham limestone 2,000+.	Thinly bedded to massive, grey finely crystalline limestone, buff coarsely crystalline ferroan dolomite; minor limy phyllite.
Conformable contact.				
Proterozoic.	Late Proterozoic.	Kaza group 6,000+.		Green schist, schistose greywacke, micaceous quartzite.

METASEDIMENTARY, SEDIMENTARY, AND EXTRUSIVE ROCKS

Cariboo Group

The Cariboo group, which underlies the greater part of the Antler Creek area, is composed predominantly of clastic rocks with lesser amounts of carbonate rocks. The rocks have been subjected to low-grade regional metamorphism and intense deformation, but they still commonly show bedding and other sedimentary features. Metamorphism has been of such a grade that muscovite and chlorite have grown to large porphyroblasts, but it has not been sufficiently high, sustained, or of such a nature that much biotite or chloritoid has been produced. Deformation has impressed a marked secondary foliation on almost all clastic rocks and some carbonate rocks. Most rocks have a marked dimensional orientation involving mica, quartz, feldspar, and even carbonate minerals, and the most intensely deformed rocks have a flaser* structure. Superimposed on the products of regional metamorphism and deformation is a local hydrothermal alteration which has bleached, silicified, chloritized, and ankeritized them.

Many of the rocks are difficult to name conveniently and accurately because of their original sedimentary and subsequent metamorphic character. Many clastic rocks of the Cariboo group are composed of poorly sorted sediments and commonly have a small percentage of grains much larger than the average; no name is generally acceptable for many such rocks even where they are unmetamorphosed. The prefix " meta " has not generally been used because of its awkwardness, but should be understood where metamorphism is not entirely explicit; for example, the term " quartzite " is used in the original metamorphic sense. Similarly, a micaceous quartzite is a metamorphic rock in which the mica is porphyroblastic. Such rocks may be called schistose grits, but the term is not entirely applicable. Most of the clastic rocks and even some of the limestones are schistose, but in any one unit the degree of schistosity may vary, depending on structural position. An argillaceous rock may range from an argillite through phyllite to a true schist as it is traced from a relatively open to a tight fold. In general the fine clastic rocks are phyllites. A difficulty arises when naming rocks that are composed of silt-sized particles. Where these rocks are micaceous, this adjective is taken to indicate metamorphism because a sedimentary rock composed of fine mica and clay minerals and silt-sized quartz should probably be called a shaly siltstone. A metamorphosed rock of silt grade that is not micaceous is called a metasiltstone.

The thickness of most of the units of the Cariboo group cannot be measured directly, and estimates are subject to considerable error because of poorness of exposure and intricacy of structure. Furthermore, in a relatively high proportion of outcrops, bedding cannot be distinguished from schistosity with certainty, and although the two are commonly parallel, such a relationship cannot generally be assumed. Although the fold structures are known in general, they are rarely known in complete detail, and measurements are liable to include duplications. Measurements have been made of sections that were judged to be the simplest, but the apparently simple sections may be ones that have been subject to thinning (i.e., on straight limbs of folds). Estimates are thus as liable to be less as they are to be more than the thickness of the original unit. Only in the Yanks Peak quartzite and, to a lesser extent, in the Cunningham limestone are estimates more than qualitative. Nevertheless, the Cariboo group as exposed in the map-area appears to be less than 4,000 feet thick.

The age of the Cariboo group is now known to be Early Cambrian and younger. Bowman (1889, p. 23c) thought the " Cariboo Schists " to be " Some part of the lower Palæozoic—perhaps even pre-Palæozoic system," but he judged the age solely by comparison of the degree of metamorphism with that of "Archean " and upper Palæozoic rocks. Johnston and Uglow (1926, p. 12) concluded the " Cariboo series " was most likely " Beltian." Lang was the first to prove a Cambrian age for some of the rocks of

* " Rocks in which lenticles of relatively unaltered material are preserved in a finely-crushed and partially-recrystallized matrix are called flaser rocks " (*Tyrrell*, 1926, pp. 282, 286).

the terrain, but he did not include the Cambrian rocks with the "Cariboo series," with which he said they were completely conformable, and so concluded the latter were late Precambrian (Lang, 1938, pp. 13–14; 1947, pp. 31–32).

No fossils have been found in the group within the map-area, and the age is assigned on the basis of archæocyathids and trilobites (late Early Cambrian) collected at Turks Nose Mountain, Kimball Creek, and other localities within a thick limestone. This limestone has been traced through a major plunging syncline into the Cunningham limestone in the vicinity of Roundtop Mountain. The Cunningham limestone is the basal formation of the Cariboo group, and thus the age of the group is Early Cambrian and younger. A full discussion of the age is given in Chapter V.

Cunningham Limestone

Distribution and Thickness.—The Cunningham limestone is exposed along the Cunningham anticlinorium on the northeast side of the map-area from Roundtop Mountain to Waverly Mountain, and intermittently to Eight Mile Lake. The formation outcrops prominently and, although there are no continuous sections, good exposures are seen on Cunningham North Mountain, after which the unit was named, and on the southeastern slopes of Waverly Mountain. At least 500 feet of limestone outcrops on Waverly and Roundtop Mountains, although the base is not exposed. Beyond the map-area more than 2,000 feet is exposed on Turks Nose Mountain.

The contact with the overlying Yankee Belle formation is completely conformable. The base of the formation was not seen within the map-area, but was observed on the upper Bowron River, Turks Nose Mountain, and Kimball Creek. The Cunningham limestone is underlain, apparently conformably, by a considerable thickness of schists, schistose greywackes, and micaceous quartzites of the Kaza group (*see* Chapter V).

Lithology.—The Cunningham limestone within the map-area consists mainly of massive, finely crystalline grey limestone or its alteration product, a ferroan dolomite. Less commonly it is well bedded. Thin white calcite veinlets ramify throughout. Widely separated thin argillaceous members occur within the limestone, and argillaceous laminæ are increasingly common toward the Yankee Belle formation.

Microscopically, the limestone is composed largely of sutured calcite crystals about 0.01 to 0.02 millimetre in diameter and a very minor amount of non-reflecting opaque matter. The limestone may contain as much as 5 per cent of detrital quartz or muscovite of a grain size similar to the calcite.

In several localities the limestone contains spherical or ellipsoidal objects of varying character and size. On Loskey Creek some spherical objects in the upper part of the formation might possibly be algal remains. They are as much as 8 inches in diameter, and bedding diverges around them. They are somewhat lighter in colour than the surrounding rock and megascopically seem to have a cellular texture, but microscopically are only distinguishable from normal limestone by the absence of opaque matter. In some strata on the ridge east of Roundtop Mountain, spherical or ellipsoidal objects of much smaller size than those at Loskey Creek form as discrete pellets about 40 per cent of the rock. The weathered limestone is mottled because the pellets are rust coloured in contrast to the middle grey of the matrix. The average cross-section of the pellets is approximately 0.5 by 0.35 millimetre, but some are as great as 5 millimetres in diameter. They are now composed of ankerite or ferroan dolomite, and a pellet is normally composed of only one crystal. Extinction is commonly wavy. A rare discernible concentric structure, displayed by microcrystalline inclusion, might indicate an oolitic origin for the pellets, but more likely they are the product of mud-feeding invertebrates (Hatch, Rastall, and Black, 1938, pp. 169–170). A third ellipsoidal form in the limestone at Turks Nose Mountain east of the map-area consists of the lime-secreting algæ *Girvanella*. These form 60 per cent of certain beds, average about 1 inch in greatest dimension, and have a marked concentric structure.

Metamorphism and Alteration.—Hydrothermal alteration has had a far more noticeable effect on the formation than has regional metamorphism. Most of the limestone has been recrystallized but still is fine-grained. On the other hand, a large part of the formation has been hydrothermally altered and recrystallized to a rusty-weathering, mottled light-grey and buff, medium crystalline ferroan dolomite rock. Rarely the altered rocks are very coarsely crystalline. The distribution of alteration is patchy, and in some instances seems to bear an areal relation to major faults, e.g., the Antler fault at Antler Creek. The alteration has obliterated all sedimentary structures and also a cleavage that is common in the unaltered limestone; the alteration probably occurred later than the deformation that caused the cleavage.

Microscopically, the altered rock is composed almost entirely of ferroan dolomite crystals about 2 millimetres in diameter. It has a granoblastic texture, but grains are bounded by rhomb faces. The crystals are moderately twinned and some show undulatory extinction. Opaque material, apart from minor limonite, is concentrated as dusty matter in very local areas.

Mode of Origin.—The character and thickness of the Cunningham limestone indicate that it was developed in a stable marine basin where detrital minerals were rare.

Yankee Belle Formation

Distribution and Thickness.—The Yankee Belle formation is named after the Yankee Belle property on Yanks Peak (Holland, 1954, pp. 17–18). It is exposed at many places along the Cunningham anticlinorium in the Antler Creek area, but best on Cunningham North Mountain, on Cunningham Creek below Roundtop Creek, and near the confluence of Shepherd and Summit Creeks. The thickness of the formation, as estimated at the least complicated sections, seems to range from about 300 feet on Cunningham Pass to at least 500 feet at the confluence of Shepherd and Summit Creeks. The latter thickness is about that indicated at Roundtop Mountain, but at the type locality the estimated thickness is 900 feet. The section on Cunningham Pass may be less than the stratigraphic thickness because it is on the limb of a large fold where thinning probably occurred.

The contacts with the Cunningham limestone below and the Yanks Peak quartzite or Midas formation above are conformable.

Lithology.—The formation is dominantly composed of brown, fine-grained phyllitic rocks, but the colour may range from grey to green and the grain size and texture from phyllitic to that of fine-grained quartzite. Changes in rock type are abrupt and without gradation. The phyllites, which may have a paper-like fissility, range in colour from light brown to light greyish-green and rarely to an intense green. Although very minor in amount compared to the phyllites, distinctive brown quartzites and metasiltstones are present in nearly all large exposures, except on Shepherd Creek above Pine Creek. Commonly they are only a few feet thick, but some may be as thick as 20 feet. A few minor thin limestone beds occur near the base of the formation, as at the confluence of Shepherd and Summit Creeks and possibly on Cunningham North Mountain. In the type locality the arenaceous strata are not present and the formation is wholly a crenulated fawn-coloured phyllite.

Microscopically, the phyllite consists of:—

	Per Cent	Approximate Average Size in Mm.
Quartz	20–50	0.01–0.1
Muscovite	20–40	0.03
Chlorite	5–30	0.03
Limonite	5–10	------------
Chloritoid	0–5	(1)
Tourmaline	0–1	------------

[1] As much as 1 mm. long.

The quartz is angular and commonly elongate, in which case it is invariably oriented parallel to the schistosity. The chloritoid, where present, is the only mineral that is not oriented parallel to the schistosity. The opaque iron ores give the characteristic brown colour to the rock unless masked by a large amount of chlorite. The tourmaline is commonly detrital, but overgrowths are invariably present, and where tourmaline is abundant it is porphyroblastic.

The more arenaceous rocks, the metasiltstones and fine-grained quartzites, are composed of:—

	Per Cent	Average Diameter in Mm.
Quartz	60–90	0.05–0.1
Muscovite	5–20	----------
Limonite (after ankerite)	5–15	----------
Feldspar	0–1	----------
Heavy minerals, including tourmaline, zircon, leucoxene	Minor	----------

The quartz grains are angular and of fairly uniform size in any one thin section. The grains are commonly strained and are either sutured or occur in a matrix of mica and limonite, where those minerals are present in sufficient quantity. The limonite commonly occurs in rhomb shapes and has replaced ankerite or siderite, which was itself porphyroblastic, and replaced quartz as well as matrix. The muscovite diverges from the dimensional orientation only to wrap around detrital grains. The detrital heavy minerals are locally abundant, especially tourmaline, which invariably has overgrowths of amber-coloured tourmaline, although the original grain may be blue, green, or amber. The original heavy minerals are rounded and have an average diameter about half that of the quartz grains, indicating that there has probably been little change in the size of the latter either by crushing or recrystallization.

Metamorphism and Alteration.—Development of porphyroblasts of chlorite, muscovite, and chloritoid in the Yankee Belle formation indicates a low-grade metamorphism. Development of paper fissility in all argillaceous rocks indicates intense deformation. Hydrothermal alteration is relatively rare and local. Chloritic Yankee Belle rocks are commonly associated with ferroan dolomite alteration in the Cunningham limestone, so that a similar addition of iron and magnesium may have affected them both. Large amounts of ankerite and limonite appear to be uniformly distributed throughout the formation and probably reflect original composition rather than alteration, even though ankerite is a characteristic vein mineral and alteration product.

Mode of Origin.—The basin in which was deposited the Cunningham limestone became the site of deposition of silt and fine sand. Sharp vertical variations in grain size indicate that the basin was swept by currents of varying intensity.

Yanks Peak Quartzite

Distribution and Thickness.—The Yanks Peak quartzite is exposed in a series of folds from Roundtop Mountain to Mount Guyet, but is not seen elsewhere, except in the northeast corner of the map-area near the confluence of Shepherd and Summit Creeks. The quartzite ranges in thickness from a few feet to 200 feet and may be absent in places. In the type locality at Yanks Peak (*see* Holland, 1954, pp. 18–19) it is about 25 to 50 feet thick, but near Roundtop Mountain it may be as much as 200 feet thick. Absence of the formation is thought to be the result of non-deposition, except in some instances, especially near Yanks Peak, where absence is the result of boudinage. The formation is conformable with the Yankee Belle formation below and the Midas formation above.

Lithology.—The formation is almost entirely a white to middle grey, medium-grained massive quartzite (*see* Plate V (A)). The grain size is uniform, and only locally are coarse or fine beds seen. A few grey argillaceous interbeds are present where the formation is thick. Bedding is usually poorly defined. Cross-bedding is not rare but is also poorly defined. The variation in colour is partly primary, but in many instances the rock is bone white where quartz veins are most numerous. The quartz veins, which are extremely rare in the neighbouring phyllites, range from minute stringers to several feet in width. Some veins contain ankerite, but the majority contain only quartz. The veins appear to be locally derived secretions.

The formation is distinctive, although in places it may be resembled superficially by some of the purer Snowshoe quartzites or Yankee Belle quartzites, if they are bleached and cut by ramifying quartz veins. The appearance of the formation throughout the map-area does not differ significantly from that in the type locality. Normally it forms a useful marker unit.

Microscopically, the formation is of simple, uniform composition:—

	Per Cent
Quartz	95–99
Muscovite	1–5
Ankerite (limonite)	0–5
Zircon, tourmaline, and leucoxene	Minor

The grain size is uniform, and, though it may range from an average of 0.1 millimetre to about 1 millimetre, the general average is about 0.3 millimetre. In relatively little deformed specimens, trains of dusty inclusions commonly outline the original sand grains, which are well rounded. These specimens now have an interlocked fabric, in which suturing normally does not involve the original grains but only the quartz cement and sericite. All quartz grains are strained and most show lamellæ and lines of liquid inclusions. Stylolites are not uncommon. Where the quartzite is greatly deformed, there has been granulation and recrystallization, and the original grains cannot be distinguished (*see* Appendix A).

Metamorphism and Alteration.—Metamorphism has not increased the grain size of the quartzite appreciably, but muscovite has grown to moderately large plates. Hydrothermal activity has had scarcely any effect on the rock.

Mode of Origin.—The Yanks Peak quartzite was laid down as a widespread but intermittent blanket of small but variable thickness, composed of well-sorted, well-rounded, cross-bedded quartz sands. The formations above and below were both formed from marine muds, silts, and minor lime deposits. All formations are comformable, and the quartzite does not appear to be a transgressive deposit. Probably the Yanks Peak quartzite was laid down during a period of crustal stability when increased currents flushed quartz sands into the basin, filling minor hollows and sweeping rises clean.

Midas Formation

Distribution and Thickness.—The Midas formation is exposed in numerous localities but chiefly in the Cunningham anticlinorium between Roundtop Mountain and Downey Creek, and in the Island Mountain anticlinorium between Antler Mountain and Island Mountain. Good exposures occur along the canyon of Antler Creek north of Beggs Gulch, on lower Grouse Creek, Downey and Shepherd Creeks, Williams Creek above Walker Gulch, and on Cow Mountain along the hydraulic ditch. The formation is named after the Midas property near Yanks Peak (Holland, 1954, pp. 19–21). Because of exceedingly close folding and general obscurity of bedding, the thickness of the Midas formation is particularly difficult to estimate. It cannot be less than about 500 feet and appears to be at least 1,000 feet thick on Island Mountain in a fairly simple section of which the base is not exposed.

The Midas formation is conformable with the underlying Yanks Peak quartzite or, where that is absent, the Yankee Belle formation. There is less certainty about the relation with the overlying Snowshoe formation. Holland (1954, p. 22) thought that there may be a slight unconformity in the Yanks Peak area. In the Antler Creek area, the base of the Snowshoe formation is almost invariably a coarse micaceous quartzite or rarely a pebble conglomerate. Most pebbles in the conglomerate are quartz but a few are Midas-like. Possibly the top of the Midas formation was slightly eroded before or during deposition of the basal part of the Snowshoe formation.

Lithology.—The Midas formation is composed mostly of black, quartzose, fine-grained rocks which, depending on grain size and degree of fissility, include phyllite, slate, argillite, or metasiltstone (*see* Plates IV (A) and VII (A)). In the southeast some black to grey, thinly bedded limestone members may be as thick as 20 feet, but from Antler Creek north only very minor limy beds occur.

An unusual dark-grey micaceous siltstone member at the base of the formation outcrops from Cunningham Creek southeastward to well beyond Roundtop Mountain, a distance of 6 miles. The member is nowhere thicker than 30 feet. Bedding in this rock, including small cut and fill and cross-bedded structures, is outlined by laminæ of "black sands" (*see* Plate IV (A)).

The general appearance of most of the Midas formation is uniform, except where it has been altered, but there are differences in grain size, composition, and fissility. The formation is characterized by its black colour and fine grain. In the western exposures the rocks are generally slightly coarser, more quartzose, and less schistose than in the east and include black quartzose slates, argillites, or metasiltstones, whereas in the eastern exposures they are commonly black phyllites, or even schists. All the various rock types of the formation present in the map-area are represented at the type localities either on Yanks Peak or at Roundtop Mountain. The Midas formation of this report includes not only the Basal and B.C. members of Hanson (1935, pp. 6–7), but also part of the Lowhee member and some rocks "below" the Basal member in undivided Richfield formation. For the most part, rocks formerly called Lowhee or undivided Richfield but now called Midas are bleached equivalents of the normal black rocks.

Microscopically, the fine black rocks which form the bulk of the Midas formation contain an extremely variable proportion of quartz and mica. The most schistose rocks were not examined microscopically, but examination of others showed the following limits:—

	Per Cent	Average Length in Mm.	Per Cent	Average Length in Mm.
Muscovite	65	0.05	2	0.03
Quartz	25	0.02	93	0.03
Opaque matter	5	......	5	......
Ankerite	5	0.05	....	......

No detrital heavy minerals are evident. The opaque matter is mostly carbonaceous, and is randomly distributed through the siltstone but commonly is in clusters in the phyllite. Large porphyroblasts of pyrite are moderately common.

The metasiltstones not uncommonly, for example on Mount Burdett and Cow Mountain, contain thin white crenulated laminæ that are visible megascopically. Most of these laminæ follow bedding, but some cross the bedding and therefore are secondary. Microscopically, they are composed of clear recrystallized quartz with a grain size two to three times that of the detrital quartz.

The basal dark-grey micaceous siltstone with black laminae is composed of:—

	Per Cent	Average Diameter in Mm.
Quartz	40–70	0.05
Muscovite and biotite	15–30	0.05
Ankerite (limonite)	0–5	......
Ilmenite	3–15	......
Other heavy minerals	2–10	0.03
Sodic plagioclase	1–3	0.02

The quartz is angular and has a definite preferred dimensional orientation parallel to the schistosity. Most of the larger grains are strained. The mica may be muscovite, biotite, or both. The rock contains an unusual abundance of detrital heavy minerals, of which the only metallic mineral is ilmenite. The heavy minerals are gradationally distributed in strata, being most abundant at the bottom of individual laminæ. It is the concentration of ilmenite that emphasizes the rock's lamination. The other heavy minerals are dominantly zircon and leucoxene, but include considerable amounts of tourmaline, and some rutile and perovskite. The heavy minerals are smaller and more rounded than the quartz grains.

The limestones are finely crystalline and normally contain 15 to 20 per cent of silt-sized detrital quartz. They commonly contain micaceous laminæ.

Metamorphism and Alteration.—The Midas formation has been metamorphosed and deformed in a manner similar to other formations of the group in general, and the Yankee Belle formation in particular. The chief difference is that porphyroblastic biotite is relatively more common in the Midas formation.

Not uncommonly the Midas formation has been altered, so that the rocks are decidedly changed in appearance. Three types of alteration are common—a regional ankeritic alteration, a local chloritization, and a local bleaching and silicification.

The ankeritic alteration is common and widespread, but only locally is so highly developed as to obscure the original character of the rock. Ankeritic porphyroblasts as great as a centimetre on a rhomb edge are common (*see* Plate IV (B)). A weathered, highly ankeritized rock has a honeycomb or vesicular appearance. Rarely porphyroblasts are so numerous that they impinge on one another, and so form an ankerite-quartz rock not sensibly different from some alteration products of limestones, micaceous quartzites, or dykes. Intense ankeritization is well illustrated in the hydraulic pit on French Creek, Lowhee Gulch, and the Richfield adit. At French Creek the most intense alteration is concentrated in crosscutting dyke-like bodies which are completely gradational to unaltered phyllite. Similar altered rocks in the Richfield adit were once thought to be sills. In both cases microscopic examination of the " dyke " rocks proved them to be altered phyllite or metasiltstone.

Chloritic rocks have a patchy local distribution that indicates they may be altered rocks. Only a slight amount of chlorite is needed to give a dark-green tint to the black rocks. Localities with green chloritic rocks include Grouse Creek near the road, Antler Creek between Nugget Gulch and Pittman Creek, and the Cariboo Gold Quartz mine.

Bleaching and silicification have radically changed the appearance of the Midas formation over relatively large areas. The once black rocks may be a rusty brown, a light purple, or white. In some cases, alteration has erased the cleavage but emphasized the bedding. The chief areas of this alteration are Mink Gulch, parts of Island and Cow Mountains, and the north side of Downey Creek; all are areas in which mineral deposits are known. The origin of these rocks is betrayed by patchiness and by colour change occurring gradationally in a short distance along strike and parallel to the plunge of fold axes. The following example illustrates the change of colour on a large scale on the northeastern limb of the Island Mountain anticlinorium. On Island Mountain the contact of the Midas and Snowshoe formations can be traced from Jack of Clubs Lake up slope for 1,000 feet, with the following sequence of changes in the Midas formation parallel to the contact: Black rocks at lake-level, patchy rocks at 300 feet, fully bleached rocks at 400 feet, and finally black rocks above 600 feet. The downward continuation of the same straight limb is penetrated by the lowest level of Island Mountain mine where irregular-shaped kernels of black rocks in predominantly light-coloured phyllites betray bleaching (*see* Island Mountain and Cariboo Gold Quartz mines). On a small scale, Plate IX(A) shows bleaching in a hand specimen.

Normal Midas rock has been bleached experimentally at moderate temperatures in a short time. A black micaceous siltstone heated in a furnace for one hour at 750 degrees centigrade became light grey with red micaceous folia. The same rock heated eight hours at 200 degrees centigrade in an oxidizing atmosphere became a mottled dark and light grey with red micaceous folia.

Microscopically, the natural alteration has cleared the rock of carbonaceous matter, irregularly increased the grain size, and produced a mosaic texture. Generally the orientation of the muscovite has not been destroyed.

Mode of Origin.—The micaceous siltstone with black laminæ at the base of the Midas formation differs from the main mass of the formation and has had a somewhat different origin. The rock is composed of fine porphyroblastic mica, quartz, and abundant heavy minerals. Both fine cross-bedding and graded bedding are the rule. The rounding of heavy minerals such as zircon indicates prolonged travel from their source, which must have been an igneous or metamorphic terrain. The member has without doubt been extensively winnowed. The fine cross-bedding indicates that the current action indicated by the Yanks Peak quartzite was still general during deposition of the base of the Midas formation.

The succeeding 1,000 feet of fine black argillaceous, quartzose, and minor limy rocks could have been deposited in deeper water than either the Yanks Peak quartzite or the micaceous siltstone. Because of their general blackness and sulphur content, they may have been deposited in a barred basin. The formation, though everywhere fine, is coarsest in the west.

Snowshoe Formation

Distribution and Thickness.—The Snowshoe formation underlies an extensive part of the map-area, particularly in the Snowshoe synclinorium. Good exposures of parts of the formation are numerous and can be seen particularly in the canyon of Coulter Creek, just west of the map-area and on Lowhee, Grouse, and Downey Creeks. The formation was named from the Snowshoe Plateau between Yanks Peak and Roundtop Mountain (Holland, 1954, pp. 22–23). The Snowshoe is the youngest known formation of the Cariboo group. Several relatively simple but incomplete sections expose more than 500 feet of grey micaceous quartzite and interbedded phyllite, particularly those on Coulter Creek, near Victoire Creek on the hydraulic ditch, and near White Grouse Creek. From Cunningham Pass to Grouse Creek 200 to 400 feet of micaceous quartzites lies below 50 feet of crenulated grey argillaceous limestone which is closely folded and simulates a much greater thickness. On Downey Creek about 300 feet of grey arenaceous rocks occur at the base of the formation beneath at least 600 to 800 feet of argillaceous and limy rocks. It appears that although the formation may be less, more likely it is greater than 1,000 feet.

Sections exposed in the Island Mountain and Cariboo Gold Quartz mines are described in Chapter VII. The structural problems have not been fully resolved, but it is believed these sections involve major duplication. For this reason they are not quoted as type sections, although they are fairly representative.

The contact with the Midas formation may be slightly unconformable. No formation younger than the Snowshoe has been recognized.

Lithology.—The Snowshoe formation is composed predominantly of clastic rocks with subsidiary limestone. In general the amount of coarse detrital particles decreases eastward and probably upward. In the west the formation is composed dominantly of coarse clastic rocks, but in the east only the lower 200 to 300 feet is dominantly coarse. The clastic rocks are subgreywackes which are characteristically poorly sorted, schistose, and deposited in very lenticular beds. The proportion of clastic to carbonate rocks in the sections exposed in the mines averages about 15 to 1. The limestones are characteristically thin, lenticular and impure.

The *arenaceous rocks* are mostly micaceous quartzites* which are normally a middle to dark grey, but can be light brown or greenish-grey. The typical rock is a dark-grey coarse- to medium-grained micaceous quartzite in which the large quartz eyes are black or opalescent (*see* Plate V (B)). In contrast to the Yanks Peak quartzite, all Snowshoe quartzites are poorly sorted and very micaceous. They are moderately to intensely fissile,

* The term "micaceous quartzite" is used to include rocks that may be variously called sheared or schistose grit, flaser-quartzite, or quartz schist, but also includes rocks of similar composition and similar but less noticeable texture.

depending largely on the relative abundance of mica. Characteristically the arenaceous beds are very lenticular and are normally intercalated with argillaceous beds or, less commonly, limestone. The clastic rocks, whether coarse or fine, have a wide variation in grain size; invariably a rock contains some grains much larger than average. For example, in a surface area of 10 square centimetres a rock composed predominantly of silt-size particles will show a few grains about 1 millimetre in diameter. The gradation of argillaceous to arenaceous rocks occurs not only by a general increase in grain size, but also by gradual accession of coarse sand. For example, a siltstone may grade into a coarse quartzite without an intervening fine quartzite or a definite discontinuity. On the other hand, large cut and fill structures can be seen, where deformation is not intense. These structures have been useful in determining the direction in which a bed faces.

Less common types among the coarse rocks include conglomerates and hornblende gneiss. Granule and pebble conglomerates are rare but widely distributed. Good examples are found on the road near French Creek, on Antler Mountain, and on Bald Mountain. Granules or pebbles are commonly flattened like pancakes (*see* Holland, 1954, p. 22 and Plate IV (A)). Conglomerates appear to be most common near the base of the unit. The composition of them is similar to the micaceous quartzites. A rare type of rock included in the Snowshoe formation is a fine hornblende gneiss found on top of Island Mountain in the upper part of the formation. The rock is greener and more banded than the micaceous quartzites. Commonly the hornblende gneiss is interlaminated with micaceous siltstone and thus is of sedimentary origin although probably tuffaceous. This rock is one of the few indications of igneous activity in Cariboo time.

Hanson's Rainbow member (1935, pp. 5–6) is composed chiefly of typical grey micaceous quartzites of the Snowshoe formation. Much of his Lowhee member is the same rock that has been bleached.

Microscopically, most of the coarse clastic rocks are very similar, whether the grain size be that of pebbles or silt. The main difference is in the amount of deformation.

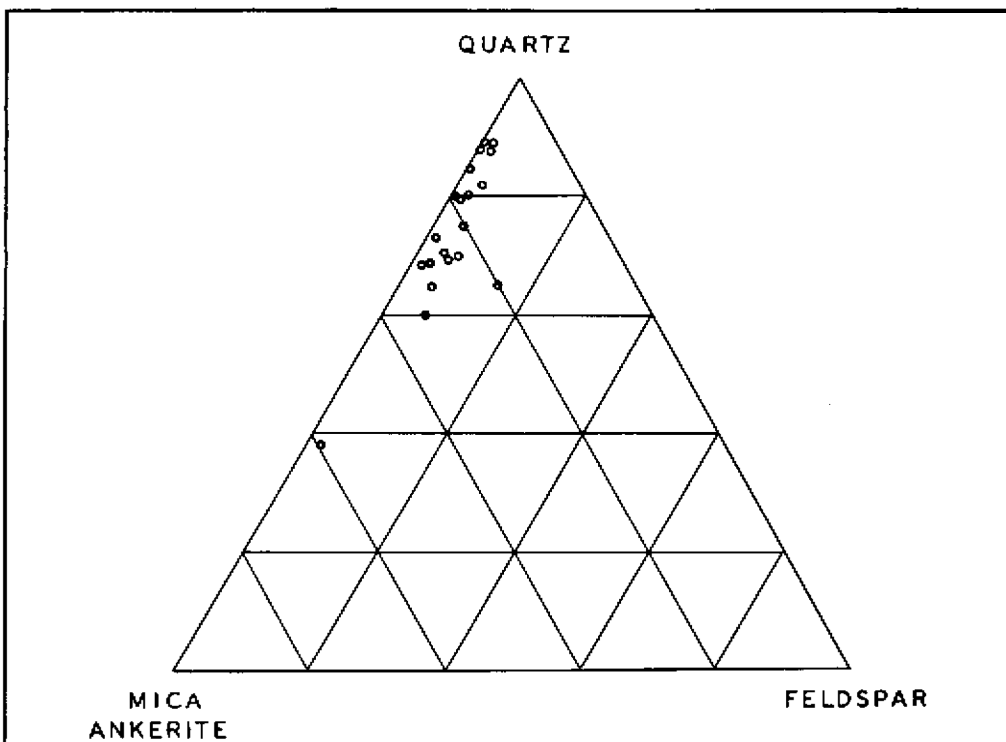


Figure 5. Mineral composition, Snowshoe formation, clastic rocks.

Figure 5 shows the variation in mineral composition. The average composition of twenty specimens is:—

	Per Cent
Quartz	74
Muscovite	17
Ankerite	5
Feldspar	4

This is equivalent to a subgreywacke by Pettijohn's classification or a low-rank greywacke by Krynine's, but is near the quartzose sandstone composition of both. The texture in the less deformed micaceous quartzites also indicates these rocks were originally subgreywackes (*see* Plate IX (B)). This specimen illustrates the extremely poor sorting, the wide variation in angularity of the large grains, and the high percentage of "matrix" quartz. The large quartz grains do not vary significantly from equidimensional, and normally they are strained. The muscovite is very well oriented, in this case parallel to the bedding. The ankerite is commonly replaced by limonite, and a small amount of pyrite may be present. The feldspar is mostly sodic plagioclase, but other feldspars are present. Invariably a few rounded grains of tourmaline, zircon, or leucoxene are present. Normally the deformation is moderately intense, and hence were it not for these examples of relatively undeformed rocks, much of the variation in grain size might be attributed to granulation. In fact, in the most intensely deformed micaceous quartzites there has been so much granulation that the rocks are flaser-rocks or mylonites (*see* Plate IX (C)). In these rocks large isolated lenticles of quartz and feldspar occur in a finely comminuted matrix of quartz and mica. In the intermediate or normal case, the large detrital grains have been deformed by flattening, and partially recrystallized, but there has been no large amount of granulation. The dark colour and opalescence common to most of the quartz and some of the feldspar grains in the deformed rocks is caused by particles of opaque matter absorbed on cleavage and fracture planes and by abundant liquid inclusions. For a detailed description of the fabric of deformed micaceous quartzites see Appendix A.

The hornblende gneiss is composed dominantly of greenish hornblende, but lesser amounts of quartz, epidote, and feldspar occur. Some of the quartz grains are rounded and hence detrital; the feldspar may also be detrital, but the other minerals are porphyroblastic. This rock occurs in thick beds and also as fine laminations within a micaceous siltstone which is composed of 80 to 90 per cent quartz and the remainder chiefly biotite.

The *argillaceous rocks* of the Snowshoe formation are mostly phyllites (*see* Plate IV (B)) but include fine siltstones. Common colours are grey, light brown, purplish-brown, or, less commonly, green. Phyllites closely interbedded with micaceous quartzites are normally grey. In the eastern part of the Snowshoe synclinorium where the argillaceous rocks are predominant, they are commonly brown. In general, phyllites of the Snowshoe formation have a lower iron content than the Yankee Belle phyllites and hence are not as brown; on the other hand, they are not as black as the Midas phyllites. The western band of what was called the Barkerville formation and much of the Baker member of the Richfield formation are composed of the Snowshoe formation where argillaceous rocks and intercalated limestones predominate over micaceous quartzites.

Microscopically, the argillaceous rocks are seen to be a heterogenous group of widely varying composition. In the following table the average composition of the rocks examined is given in Column A, and the variation found within 1 centimetre in a specimen of banded phyllite and siltstone in Columns B, C, and D.

	A	B	C	D
Mica	40	35	80	20
Quartz	37	45	5	25
Limonite	18	20	15	55
Carbonate	5	----	----	----

The average diameter of quartz grains in these rocks ranges between 0.02 and 0.05 millimetre, and the average long dimension of mica crystals is of the same order. Quartz grains are angular, inequant, and invariably well oriented in the schistosity. The micaceous mineral is commonly muscovite, less commonly chlorite. The amount of carbonate, either calcite or ferroan dolomite, may increase gradationally to a limestone.

Calcareous rocks form a small percentage of the Snowshoe formation, but are important because of gold-bearing pyritic replacement of certain beds. Limestones may be black, white, grey, or mottled. Because of alterations to ferroan dolomite or ankerite, some turn brown on weathering. Only the thicker limestones are pure and free from argillaceous laminæ. Limestones are rarely more than 50 feet thick and most are less than 20 feet. The beds are lenticular and some are pod-like. Limestones are more commonly associated with argillaceous rather than arenaceous strata in the formation. The Baker limestone beds of the Snowshoe formation have been extensively explored because they are the site of most known replacement deposits. These beds vary widely in thickness, colour, and content of argillaceous laminæ. The variation in thickness is partly the result of flowage. In highly deformed areas the component calcite crystals have a marked dimensional and lattice orientation, giving the rock a definite planar structure although it may not be fissile. The crystals average about 0.35 by 0.2 millimetre in section and are highly twinned and lamellar.

Metamorphism and Alteration.—The metamorphism of the Snowshoe formation is similar to that of other formations in the group. The common porphyroblastic minerals are muscovite and chlorite, whereas biotite is rare. The hornblende gneiss is a rare but interesting exception. The hornblende and epidote are definitely porphyroblastic, whereas the quartz is detrital. The gneiss is interlaminated with a quartzose metasiltstone that contains biotite as the porphyroblastic mineral. It would seem that composition, not temperature or pressure, was the controlling factor in the metamorphism of this rock. Deformation has impressed a general schistosity on most of the Snowshoe formation in common with other rocks of the group, but it has also caused some particularly striking effects. The clastic rocks have in large measure become flaser-rocks, in which the larger grains have become flattened and acquired their characteristic black or opalescent colouring. All these effects are particularly striking microscopically (*see* Appendix A). The most remarkable features of the other rock types are the marked flowage of the limestones and the intense crumpling of the phyllites.

The Snowshoe formation has been altered, as has the Midas formation, but the effect has been less intense. Bleaching is less noticeable, but many of the brown quartzites were originally grey and have been bleached. Good examples of bleaching occur in the Cariboo Gold Quartz mine (*see* pp. 75–77).

Mode of Origin.—The sedimentary structures, the lenticularity of units, the variation of rock type and grain size, and the original mineral composition together probably indicate a marine deltaic origin for rocks of the Snowshoe formation. The coarsening and apparent thickening of the clastic rocks to the west and the increase in the amount of limestone to the east probably indicate a western source. A similar direction of coarsening is indicated in the Midas formation. The implication is that there was land to the west, and that it was probably an igneous or metamorphic terrain. The Cariboo group as a whole shows a progression from sediments typical of a stable environment to those typical of an unstable one.

Slide Mountain Group

The northeastern part of the Antler Creek area is underlain by sedimentary and volcanic rocks of the Slide Mountain group. The group comprises conglomerate, greywacke, argillite, chert, basic volcanic rocks, and a minor amount of crinoidal limestone. The assemblage is intruded by Mount Murray sills, which are similar in composition to the Slide Mountain extrusive rocks; with some exceptions the intrusive rocks can be distinguished in the field from the extrusive. The part of the group that was examined contains 4,000 feet of stratified rocks and 800 feet of Mount Murray sills. Measured sections and a discussion of their accuracy are included in Appendix B. The contact with the Cariboo group has not been observed, but there is no doubt that it is unconformable.

The Slide Mountain group within the map-area forms the southwestern limb of a structural trough 10 miles wide. The rocks are moderately folded but are neither regionally metamorphosed nor fissile and thus contrast with rocks of the Cariboo group. The age of the Slide Mountain group is probably Carboniferous, on the evidence of some poorly preserved fossils from the Greenberry limestone member. The group has been tentatively correlated with the Cache Creek group on the basis of lithological similarity.

The nomenclature of Johnston and Uglow has been revised. The Guyet and Antler formations have been retained, the Greenberry limestone reduced to a member of the Guyet formation, and the Waverly formation abandoned. The Guyet formation is now known to change rapidly in lithology along strike and to include not only conglomerate but also much argillite, greywacke, and volcanic rock. The base of the formation has been mapped southwest of the position shown by Johnston and Uglow on Waverly Mountain and Mount Howley. The Greenberry limestone has been reduced to a member because it is thin and because it is intermittent and interfingers with conglomerate near the top of the Guyet formation. The Waverly formation has been abandoned because volcanic rocks are intercalated throughout the whole group, rather than being localized, as believed by Johnston and Uglow. The definitions of the Antler and Guyet formations have been expanded to include the volcanic rocks.

Guyet Formation

Distribution and Thickness.—The Guyet formation outcrops along the northeastern border of the map-area from Cunningham North Mountain to Summit Creek. Exposures are good in most places where the conglomerate is thick—e.g., Summit Creek, Alex Allan Creek, Mount Guyet, and the northwestern slopes of Mount Murray—but are poor where other rocks predominate.

The Guyet formation is 1,125 to possibly 1,500 feet thick. Measured and generalized sections are included in Appendix B. The lower contact was not seen. The upper contact is placed at the highest coarse clastic bed in the Slide Mountain group. The Guyet formation thus includes all the coarse sedimentary rocks in the group, all of which are within the lower 1,500 feet. Either the Greenberry limestone member or a calcite-bearing volcanic rock may occur in the uppermost part of the formation and may, in the absence of good exposure, be taken as the top.

Lithology.—The Guyet formation as described by Johnston and Uglow consisted chiefly of conglomerate, but this is so in only two areas, near Slide Mountain and Mount Guyet. In general it is a heterogenous assemblage of boulder to granule conglomerate, greywacke, argillite, clastic crinoidal limestone, and volcanic flows and breccias.

The *clastic rocks,* from conglomerate to argillite, all belong to the greywacke suite. The conglomerate is a massive dark-grey to brown polymictic* rock. It is dominantly a pebble-conglomerate, although the particle size ranges from that of boulders to granules. Bedding is rare; evidence of it is seen as the intercalation of greywacke lenses or, near the base of the formation, as an abundance of parallel schistose rock fragments. No imbrication was seen. Boulders and cobbles are sub- to well-rounded and pebbles are angular to well-rounded. The rock types include all members of the Cariboo group and also vein quartz, highly limonitic rock, quartz porphyry, and basic volcanic rocks. The general appearance remains uniform, although the character of the pebbles and cobbles changes upward in the formation. Near the base many of the pebbles are schistose; the largest cobbles are basic volcanic rocks. On Summit Creek near the base of the formation a cobble conglomerate contains some greenstone blocks as much as 4 feet in diameter, and slightly higher in this section there appears to be a transition from a normal conglomerate, to one with a volcanic matrix, to agglomerate. Commonly toward the top of the formation, greenstone cobbles and schistose pebbles are less numerous and vein quartz pebbles more numerous. On Cunningham North Mountain the largest pebbles are similar

* Composed of many different rock types, some of which are metastable in the conglomeratic environment.

to the Cunningham limestone. The matrix of the conglomerate forms as much as half the rock, and is similar to the finer-grained rocks of the formation.

The conglomerate is in general silicified, so that it forms a dense hard rock even though a large proportion of the fragments were originally soft or easily weathered; in a few instances, where not silicified, it is a soft, " rotten " rock most unlike the normal conglomerate. In the silicified conglomerate many of the phyllite pebbles are now wholly or partly replaced by chert, although they retain their original characteristic shape and colour. In some instances where the conglomerate was composed of a variety of schistose rocks, the whole has been converted into a nearly uniform cherty rock. It should be emphasized that the underlying Cariboo group is not known to contain chert.

The fine-grained sedimentary rocks range from grey and brown greywacke through siltstone to grey argillite and slate. The slate and argillite are intercalated with greywacke and volcanic flows and are not phyllitic, as are the Yankee Belle or Midas argillaceous rocks.

Microscopically, the greywackes and fine conglomerates are of more varied mineral composition than the micaceous quartzites of the Snowshoe formation (*see* Fig. 6). The average composition of twelve specimens is approximately:—

	Per Cent
Quartz	50
Feldspar	12
Rock Fragments	25
Mica and Chlorite	13

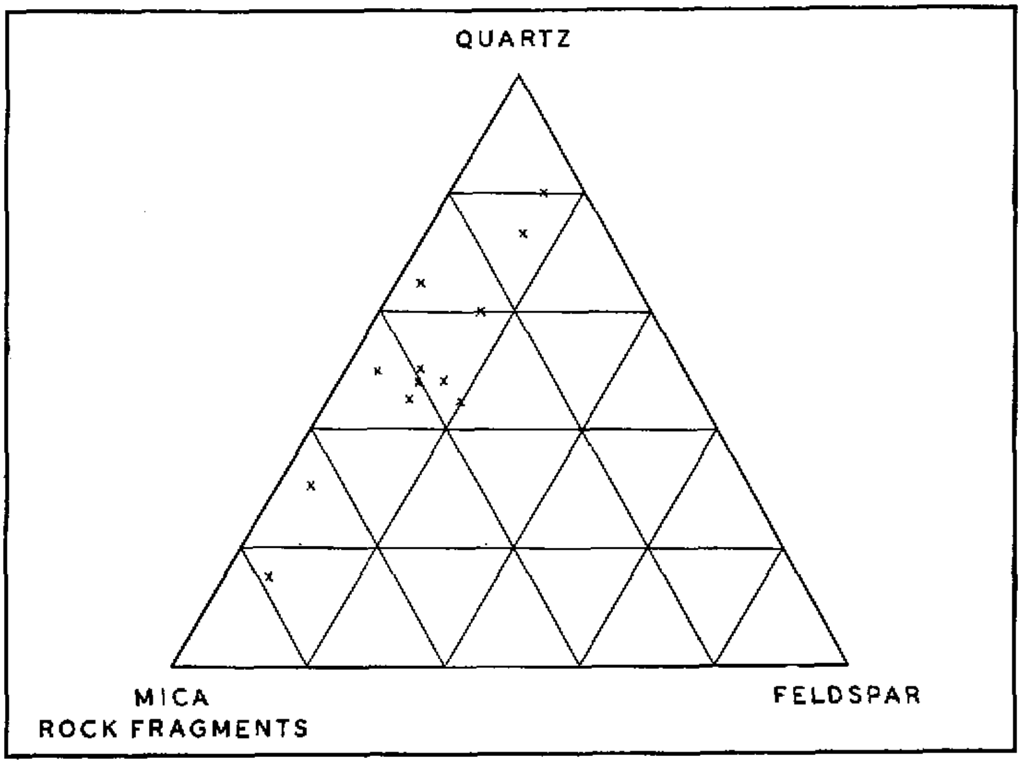


Figure 6. Mineral composition, Guyet formation, greywackes.

In all specimens the sorting is poor and, although the quartz may be sub-rounded, the rock fragments are angular. The compaction of these rocks commonly has squeezed the fine-grained phyllitic rock fragments into the interstices between the stronger grains, making the fragments look even more angular than they were originally. There are no prominent foliations; bedding is uncommon, fracture cleavage rare, and schistosity absent.

A large number of the quartz grains have characteristics such as lamellæ or strain shadows that probably indicate they were derived from the Cariboo group, but others are clear and may have come from quartz veins or volcanic rocks. In some specimens, microcline is present in excess of plagioclase, but normally plagioclase is the dominant feldspar. In either case the feldspars are so highly sericitized that they must have been altered after deposition. Some grains possess highly erratic twinning, such as that observed in feldspar grains of the mylonitic Snowshoe micaceous quartzite. With the exception of some detrital muscovite, the mica is fine-grained. Sericite has replaced quartz in some cases as well as feldspar. Rarely chlorite is the dominant micaceous mineral. The rock fragments include phyllite and micaceous siltstone, which in some specimens have been partly or completely replaced by chert.

Calcareous rocks are rare and represented only by the Greenberry member. This limestone was considered a formation 400 feet thick by Johnston and Uglow, but it is less than 100 feet thick. Possibly some of the calcitic volcanic breccias and flows described below were included by them in the formation. The limestone occurs intermittently as lenses from the ridge east of Mount Guyet to Summit Creek, and is thought to represent one horizon. It occurs near or at the top of the formation but interfingers with the conglomerate. The best examples of interfingering occur on Alex Allan Creek and Mount Murray.

The Greenberry limestone member is a grey, buff, or mottled medium crystalline limestone which in some places is composed wholly of clastic crinoid stems. In other places the only recognizable crinoid stems are contained in white to black chert nodules or masses. Only at Summit Creek, where thin grey argillaceous limestone grades into argillite along strike, is there no evidence of crinoid stems. Ellipsoidal chert nodules are oriented with the major axes parallel with bedding. Other evidence of bedding is rare. Some relatively large masses of structureless white chert adjacent to the limestone appear, like the nodules, to have replaced the limestone.

Microscopically, the member is about 80 per cent calcite and 20 per cent quartz. The crystal size of the calcite ranges from 0.003 to 5.0 millimetres but averages about 0.6 millimetre. The crinoid stems are not readily visible microscopically because of recrystallization. The quartz is gathered in clots as clear mosaics of grains ranging from chert size to 0.5 millimetre, but mostly the smaller. There are no recognizably detrital grains.

The *volcanic rocks* include pillow lavas, breccias, and minor pyroclastic rocks. All are composed of basic greenstone and are superficially the same—greenish-grey aphanitic volcanic rocks. Pillow lavas are best exposed on Waverly Mountain. The pillows range from 1 to 4 feet in long dimension. They are separated by little matrix and show little variation in texture apart from rare inclusions of limestone in them. Some flows appear massive, except for obscure flow or fragmental structures. Flow breccias are best exposed south of Mount Greenberry and on Mount Howley. The size and vesicularity of adjacent fragments varies widely. Rocks definitely of pyroclastic origin are rare.

The formation includes some unusual volcanic rocks. One of these is a flow breccia that contains considerable quantities (as much as 30 per cent) of coarsely crystalline grey to black calcite. In some places the calcite appears to be a cement between volcanic blocks, but in others it occurs in lenticles or bands parallel to flow structure and appears to be an integral part of the flow. These rocks occur near the top of the formation, below the Greenberry limestone member; the best exposures are on Mount Howley and between Yellowhawk and Jubilee Creeks. Another type contains large quantities of limestone fragments as much as 6 inches in diameter. Such rocks occur chiefly at the base of the formation and are best exposed on the north end of Mount Guyet. A similar rock on Waverly Mountain is a dyke (*see* pp. 44–45), and in small exposures it is impossible to determine whether such rocks are extrusive or intrusive.

Microscopically, the extrusive rocks are all similar despite differences of fabric. They are also similar to the Mount Murray intrusive rocks, though not so well crystallized. The flows are microporphyritic rocks composed of feldspar and pyroxene or rarely amphibole microphenocrysts, chlorite, calcite, microcrystalline epidote, and opaque matter. Phenocrysts rarely form more than 10 to 20 per cent of the rock. Not uncommonly the pyroxene is completely altered to chlorite with anomalous interference colours. Rarely a micro-diabasic fabric can be seen in centres where microphenocrysts are common. More commonly there is a faintly radial arrangement of microphenocrysts. Ovoid structures indicative of original palagonite are seen rarely. Some of the very fine-grained rocks are a semi-opaque mass. In some of the limestone inclusions the grain has been haphazardly enlarged, and irregular porphyroblastic andesine has developed.

The volcanic rocks in the Antler formation are similar to those in the Guyet formation, except that the calcitic types are absent. A chemical analysis of a flow rock from the Antler formation is shown in Table IV. This is a basaltic rock with spilitic affinities.

Metamorphism and Alteration.—The Guyet formation has not been regionally metamorphosed or much deformed except locally. Ankeritization is rare and nowhere intense. However, there has been a cherty silicification that has bonded and replaced rock fragments in the conglomerate and replaced limestone in the Greenberry member. This matter will be discussed further under Antler formation.

Mode of Origin.—The Guyet conglomerate is composed largely of detritus that is recognizably derived from the Cariboo group and Proserpine dykes. The rocks of the Kaza group exposed northeast of the Slide Mountain group are characteristically different from the Cariboo group (*see* Chapter V), and furthermore contain no dykes of any sort. Therefore, it is concluded that the source of the Guyet conglomerate was to the southwest of the present outcrop belt.

The environment in which the Guyet conglomerate was deposited is indicated by the great variety of rock types present, many of which are metastable; the relatively low degree of rounding and sorting; the intercalation of sediments and pillow lavas of marine origin; the lateral gradation of thick sections of conglomerate to fine clastic rocks with minor pebble beds. Taken together these characteristics indicate an environment such as the mouth of a torrential stream. The thick conglomerate sections at Slide Mountain and Mount Guyet may be the deposits of two large streams between which finer-grained rocks accumulated.

The calcitic flow breccias may be the result of lavas flowing over crinoid gardens, such as those that provided the crinoid stems in the overlying Greenberry limestone member.

Age.—The dating of the Guyet formation and of the Slide Mountain group is dependent on fossils in the Greenberry limestone member. Johnston and Uglow found a fragmentary suite of fossils at Two Sisters Mountain, north of the present map-area, and Mount Greenberry, but the localities are not marked on their map. E. M. Kindle, who examined the fossils, is quoted by Johnston and Uglow (1926, pp. 20–21) 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 present *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.

In spite of detailed search, the writer found no fossils even as indicative as those found by Johnston and Uglow. However, suites containing crinoid stems collected from several localities were sent to Professor Howell at Princeton University for determination. He believed them to be either Devonian or Carboniferous, possibly Mississippian, but the poor preservation and lack of distinctive features prevented a more precise determination.

The rocks of the whole Slide Mountain group are very similar lithologically to those of the Cache Creek group, whose age ranges from Late Carboniferous to Latest Permian. Until further evidence accrues, the group should be regarded as Carboniferous, possibly Mississippian.

Antler Formation

Distribution and Thickness.—The Antler formation is exposed along the northeastern border of the map-area from Slide Mountain to the ridge east of Mount Guyet. The best exposures are on Slide Mountain, Mount Murray, and Mount Howley. Measured sections at the latter two localities are contained in Appendix B. On Mount Murray about 3,000 feet of stratified rocks and 800 feet of sills were examined. The Guyet and Antler formations are conformable. The top of the Antler formation was not seen. Similar rocks extend eastward intermittently to Bowron Lake where they are well exposed.

Lithology.—The Antler formation consists of fine-grained sedimentary and basic volcanic rocks. Characteristic of the formation are banded cherty rocks and dark-green pillow lavas.

The *sedimentary rocks* include chert, argillite, cherty siltstone, cherty argillite, and fine greywacke. In hand specimen many of these types are distinguished with difficulty. The rocks are commonly coloured dark to light grey or buff, less commonly white or green, and rarely red. Normally the rocks are banded, except in much of the lower 1,000 feet of the formation. Where weathering has emphasized texture, fine laminations can commonly be seen throughout the formation, even within the lower 1,000 feet.

The banded rocks are all superficially similar. They commonly consist of a dominant rock type in beds 1 to 2 inches thick, and a minor type in beds less than one-half inch thick. The dominant type may be chert, cherty siltstone, cherty argillite, or fine greywacke, and the minor type may be argillite or cherty argillite. The minor type is normally more micaceous. Plate VI (A) shows banded cherty fine siltstone and argillite. In the lower 1,000 feet of the formation in which banding is not common the main rock type is argillite. Irregular masses in the argillite may be composed of cherty argillite which grades imperceptibly to normal argillite. These irregular masses are not oriented with the bedding. Rafts of sedimentary rocks in the large complex sills on Mount Murray and Slide Mountain are composed almost entirely of chert, although they may have a banded structure.

The banded sedimentary rocks contain small recumbent folds which appear to be unrelated to the compressional folding of the Slide Mountain group. Individual structures involve at most 4 to 5 feet of banded rocks. The folds are commonly attenuated and sharp but may be complex and lack a truly stratiform nature. If regarded as dragfolds, they normally indicate interbed movement, which is the opposite of that which would evolve during the major folding if the beds are right side up. Little possibility exists of local overturning, because all pillow lavas and many sedimentary beds can be proved to face upward. The structures most likely indicate primary slumping in beds with an initial dip to the northeast.

Microscopically, all the sedimentary rocks have many features in common—fine grain, clear chert ovoids, and the same suite of minerals. Figure 7 shows the variation in mineral composition. It can be seen that almost all specimens contain both detrital and cherty quartz. Specimens which appear to be true cherts macroscopically are found commonly to be cherty siltstones. The detrital component is mostly quartz but includes zircon, tourmaline, and sodic plagioclase. Detrital grains are normally less than 0.03 and greater than 0.01 millimetre in diameter and extinguish uniformly. The particles are angular, except for the heavy minerals and rare large quartz grains (0.2 mm.). In some specimens minute quartz (less than 0.005 mm.) of the matrix also seems to be detrital because the grains extinguish uniformly, are angular, and are bounded by an irregular packing of opaque matter. More commonly the matrix is composed of cryptocrystalline quartz or chalcedony which has sutured, even, black boundaries and a wavy extinction. Porphyroblastic micaceous minerals form 10 to 20 per cent of the rock. Normally the micaceous mineral is sericite, but it may be biotite or chlorite. The mica plates are generally about 0.015 millimetre wide and 0.005 millimetre thick.

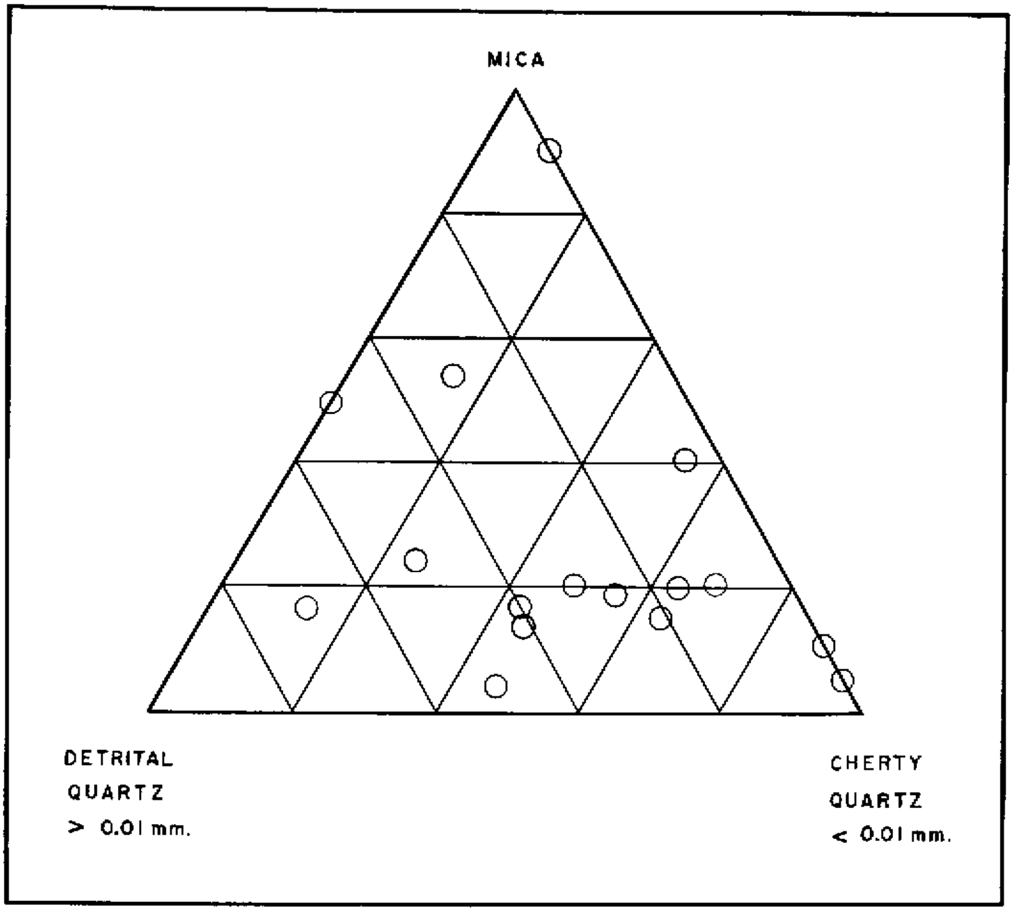


Figure 7. Mineral composition, Antler formation, sedimentary rocks.

The banding of the rocks is seen microscopically to be at least partly due to variation in mica content; highly micaceous laminæ separate bands of chert or cherty siltstone. The micaceous laminæ may themselves be cherty.

Almost all specimens studied contain patches of microcrystalline quartz or chalcedony that contrast with the surrounding rock in opacity and texture. These patches are normally ovoid, but in some specimens they are plate- or rod-like. They vary in size but are commonly large compared to the biggest detrital quartz grains. Some of the patches have vestiges of a form that indicate that they may have been organic; i.e., tube-like, or vague spiral or cellular shapes. Professor H. E. Wheeler, of the University of Washington, examined a typical specimen but was unwilling to say more than that the patches may have been organic.

The cherty rocks show evidence of replacement, solution, and recrystallization. Veinlets of fine quartz or chalcedony ramify through the cherts and in some instances form as much as 5 per cent of the rock. Some veinlets are bridged by detrital grains or micaceous laminæ, showing there has been no dilation but only replacement or recrystallization. Some large, recognizably detrital grains are recrystallized partly or completely in a cherty manner. The unrecrystallized parts of such grains are highly strained. The presence of some stylolites indicates local solution of quartz.

The *volcanic rocks* of the Antler formation are chiefly basaltic pillow lavas, dark grey-green aphanitic or microporphyritic rocks. The pillows are massive and have little matrix about them. A rude radial and concentric jointing near the peripheries is the only internal structure. In many exposures the pillowed structure can only vaguely be seen.

Microscopically the freshest specimens of volcanic rock are composed approximately of:—

	Per Cent	Average Size in Mm.
Microphenocrysts—		
Plagioclase, An_{20} approximately	10	0.3 x 0.07
Chlorite and calcite after pyroxene or olivine	2	0.4 x 0.3
Augite	15	0.05
Epidote	10	
Semi-opaque groundmass	63	

The plagioclase is clouded and sodic, the augite is fresh and calcic. The groundmass normally has a vaguely radial or spherulitic texture as do some knots of phenocrysts. Augite and plagioclase phenocrysts commonly occur in interlocking semi-diabasic knots. These knots may involve as few as two crystals, a plagioclase lath with an hour-glass or pinched shape surrounded by a grain of augite. Many specimens are altered to a semi-opaque fine-grained mass of chlorite, epidote, and calcite.

In a number of localities the volcanic rocks contain irregular masses of dark grey-green chert which grades imperceptibly to normal volcanic rock. The chert masses are thus difficult to distinguish in the field even though they truncate flow structures in the volcanic rocks. The largest mass found, approximately 30 feet in diameter, was on the southwestern slopes of Mount Murray.

A chemical analysis of a representative volcanic rock from the Antler formation is shown in Table IV in comparison with diabases of the Mount Murray sills and other similar rocks. The evidence of fabric and mineral and chemical composition all indicate that the volcanic rocks of the Slide Mountain group are related in origin to the Mount Murray intrusive rocks (*see* pp. 42–45).

Mode of Origin.—The source of the fine detritus in the Antler formation appears to have come from the southwest as it did in the Guyet formation. Slump structures in the banded rocks of the Antler formation are directed from the southwest, so that initial dip must have been toward the northeast.

The origin of cherty rocks has been discussed by many authors without general agreement. Reviews of the theories of origin can be found in Pettijohn (1949, pp. 328–332) and Bramlette (1946, pp. 41–46). In summary, chert is believed to have formed epigenetically or syngenetically by organic or inorganic means. The ultimate source of the excess silica is commonly attributed to volcanism because of the world-wide association of chert and volcanic rocks, but it is also attributed to weathering.

No single theory adequately explains all occurrences. In the following two examples of Tertiary age in similar settings, particularly clear evidence leads to different conclusions. Bramlette (1946) has shown that the Monterey bedded cherts are largely the result of redistribution of silica and compaction of beds containing large but variable amounts of diatoms together with some silica reinforcement resulting from alteration of pyroclastic rocks. On the other hand, Park (1946, p. 313) has shown that in the Olympic Peninsula of Washington, jasper (ferruginous chert) is associated with spilitic pillow lavas and red rocks (limy shales), and that single bodies of jasper have replaced both rocks.

In British Columbia, Dawson (1896, p. 41) postulated that the " cherty quartzites " of Cache Creek were silts or argillites which were silicified subsequent to deposition. He noted the association with volcanic rocks near Cache Creek and throughout the world. Cairnes (1924, pp. 41–42), following Davis (1918, pp. 235–432), advocated a theory that involved contemporaneous precipitation of silica from emanations associated with lavas as the origin of Cache Creek cherts. Recent authors writing on Cache Creek rocks

(Armstrong, 1949, pp. 36–39; Duffell and McTaggart, 1952, pp. 18–19) have followed Cairnes.

The origin of the cherty rocks of the Slide Mountain group is not simply explained. Their development seems to involve the initial formation of fine-grained highly quartzose banded sediments and their subsequent recrystallization, solution, and replacement. Factors bearing on the problem are reviewed below:—

(1) Much of the Guyet formation has been silicified in a cherty manner. Some conglomerate composed originally of phyllite fragments has been silicified so that it resembles a chert pebble conglomerate. It would seem impossible for silica gel to exist in sufficient quantity in the depositional environment to produce the silicification (*see* p. 34).

(2) Chert nodules and masses in limestone which preserve and replace abundant crinoid detritus are proof of epigenetic chert. As this limestone is clastic and interfingers with conglomerate, the environment would seem unsuitable for the precipitation of silica gel and penecontemporaneous replacement of limestone (*see* p. 35).

(3) Chert masses which truncate flow structures in volcanic rocks are proof of epigenetic chert (*see* p. 39).

(4) The matrix of a small quartz-feldspar porphyry sill has been in some places entirely replaced by fibrous cherty quartz. This shows that some cherty replacement occurred not only later than deposition but after intrusion (*see* Intrusive Rocks).

(5) Chert ovoids occur in nearly all bedded cherty rocks. If these were originally organisms, as many appear to have been, it follows that: (*a*) If siliceous they have been filled in with silica, (*b*) if calcareous or chitinous they have been entirely replaced. If they were originally lapilli or volcanic dust, they have also been subject to alteration and replacement (*see* p. 38).

(6) Veinlets of fine quartz or chalcedony occur in chert, cherty argillite, and quartz-feldspar porphyry. Some of these veinlets are definitely formed by recrystallization or replacement rather than by fracture filling (*see* p. 38).

(7) Some detrital grains of strained quartz have been partly or wholly recrystallized into a cherty mass (*see* p. 38).

(8) Rafts of sediments contained in sills are almost wholly chert although retaining a banded form. This may be partly the result of recrystallization but would seem also to involve replacement (*see* p. 37).

(9) The character of the bedded rocks as they are described on pages 37 and 38 is important. They are mostly banded at similar intervals regardless of their degree of "chertiness." The interbeds are more highly micaceous than the cherty rocks they separate. There is abundant fine detrital quartz in argillites, siltstones, cherty argillites and siltstones, and in some true cherts. Even the minute quartz of the matrix appears to be detrital in some cases. There is every gradation between chert and argillite. Thus the original rocks seem to have been highly charged with fine detrital quartz in beds 1 to 2 inches thick and separated by thinner argillaceous rocks.

An interpretation of such diverse evidence implies more than one source of silica and more than one origin of the chert.

Most of the Antler formation was originally composed of interbedded, very fine quartzose and argillaceous muds. Recrystallization alone may account for the cherty aspect of some of the banded rocks, but there can be no doubt that there has been much epigenetic silicification. It is not impossible for siliceous organisms or tuff to have been dissolved and redistributed as opaline silica to form cherty matrix, but the cherty silicification of large amounts of conglomerate and of some lava, limestone, and intrusive rock cannot adequately be explained in this way.

TERTIARY(?) GRAVELS

Angular gravels partly cemented by limonite commonly occur in minor amounts below the glacial till and stratified silts, sands, and gravels exposed in the creek bottoms by placer-mining. Many of the paystreaks in the placer-gold deposits of the region were at the base of these cemented gravels. Johnston and Uglow (1926, p. 25) showed that they are probably of Tertiary age.

INTRUSIVE ROCKS

Intrusive rocks are comparatively rare in the Antler Creek area. They are most abundant and form the largest bodies in the northeastern part of the area where they intrude the Slide Mountain group as sills and part of the Cariboo group as dykes. In the remainder of the area there are only a moderate number of small dykes.

Johnston and Uglow divided the intrusive rocks into two groups—the Proserpine intrusions and the Mount Murray intrusions. The subdivision was made on the basis of the fact that the Proserpine intrusions were acidic and were not seen to invade the Slide Mountain group, whereas the Mount Murray intrusions were basic and cut both the Cariboo and Slide Mountain groups. They stated that the lack of younger consolidated rocks did not permit dating the Mount Murray intrusions, but they tentatively correlated them with the Coast Range (Jurassic) period of intrusion.

This usage is maintained in this report. One acidic sill was seen in the Slide Mountain group, but it is unlike the Proserpine dykes in composition, texture, and alteration, and hence is not thought to be a member of the Proserpine intrusions. The Mount Murray intrusions are dominantly diabasic bodies which are related to the basalts of the Slide Mountain group areally and in composition, and therefore most probably in time; hence they have been classed provisionally as Carboniferous rather than Jurassic. Most of the basic dykes in the Cariboo group are probably related to the diabase sills, but some, particularly lamprophyre dykes, are younger.

PROSERPINE DYKES

Distribution.—The Proserpine dykes intrude the Cariboo group. They are distributed throughout the map-area and are well exposed on Grouse, Wolf, and Antler Creeks, and in prospecting trenches on Mount Proserpine. Most dykes are 1 to 4 feet wide and the largest are 10 to 20 feet wide.

Lithology.—The Proserpine dykes are felsites that in general are so ankeritized that they weather a characteristic reddish-brown. They are usually aphanitic but may be microporphyritic. No dyke is fresh; most are highly ankeritized, and many are schistose. Commonly the dykes and their adjacent wallrocks are so highly ankeritized it is difficult to distinguish one from the other in the field.

Microscopically, a typical dyke is composed of:—

	Per Cent
Potassic feldspar	35
Oligoclase	15
Quartz	10
Ankerite porphyroblasts	30
Muscovite	8
Limonite	2

The feldspars are highly sericitized and the mafic minerals entirely altered. The original fine-grained texture has been largely obliterated by the development of large ankerite porphyroblasts and by muscovite which is oriented with a microscopic schistosity. Some dykes are composed entirely of ankerite, muscovite or fuchite, and quartz, and are indistinguishable from similarly altered sedimentary rocks.

Structural Relations.—The Proserpine intrusions are invariably steeply dipping and so are termed dykes, although they are in general concordant with the foliation. They were intruded after the major folding of the Cariboo group, but on lower Grouse Creek some of the dykes are folded with the Midas rocks. These latter dykes either followed pre-existing folds or were involved in a second period of folding.

Age.—As pointed out by Johnston and Uglow, cobbles similar to the Proserpine rocks are found in the Guyet conglomerate, but intrusive bodies similar to the Proserpine rocks are not found in the Slide Mountain group. The Proserpine intrusions post-date the major folding of the Cariboo group but antedate the deposition of the Slide Mountain group.

Mount Murray Intrusions

Distribution.—The Mount Murray intrusions invade both the Cariboo and Slide Mountain groups. They are more numerous in the latter group, in which they occur most commonly as sills. The largest sill in the map-area is approximately 700 feet thick, but this thickness includes nearly 200 feet of rafts of sedimentary rocks. Most sills are about 300 feet thick. The largest dykes are in the Cariboo group adjacent to the Slide Mountain group or along the contact between them and may be as much as 400 feet wide. Elsewhere in the Cariboo group the dykes may be as much as 50 feet wide but are normally much less.

Lithology.—With few exceptions, the Mount Murray intrusive rocks are dark greyish-green in colour and of fine to medium grain. Numerically and by volume the great majority are diabase. The remainder are diverse types, such as inclusion-filled aphanitic greenstone dykes and a quartz-feldspar porphyry sill cutting the Slide Mountain group; and small basic porphyry and lamprophyre dykes cutting the Cariboo group.

The *diabases* are dark greyish-green rocks that weather to a rough dark reddish-brown surface. Specimens from the sills all show some degree of diabasic texture which commonly is coarse enough to be recognized in the field. Exposures of the sills are commonly massive with no pronounced jointing. In many dykes in the Cariboo group the diabasic texture has been largely obliterated by alteration and the development of schistosity. A very minor amount of ultramafic rocks, pyroxenites or serpentines, occur within the diabasic sills or as dykes not far from them. The ultramafic bodies grade rapidly toward their margins to normal diabase. The texture of the pyroxenites indicates some form of crystal accumulation.

Table III.—Mineral Composition of Mount Murray Diabases

MODES

1		2		3	
	Per Cent		Per Cent		Per Cent
Augite ($Ca_{42}Mg_{42}Fe_{16}$)	28.4	Chlorite after augite or hornblende	51	Chlorite	27
Chlorite after augite	9.4	Oligoclase	39	Clinozoisite	26
Oligoclase (An_{15-18})	58.5	Albite	7	Biotite	8
Leucoxene	3.5	Plagioclase intergrowth	1	Andesine (An_{35})	33
Calcite	0.2	Leucoxene	2	Leucoxene	5
				Pyrite	1

CALCULATED NORMS

	1	2	3
	Per Cent	Per Cent	Per Cent
Quartz	....	3.10	.....
Corundum	......	......	2.45
Orthoclase	......	......	2.22
Albite	29.34	25.15	40.35
Anorthite	23.34	16.96	24.46
Diopside	14.09	5.56	......
Hypersthene	21.38	34.83	14.86
Olivine	1.63	......	2.72
Magnetite	2.09	5.10	5.57
Ilmenite	2.89	2.13	1.98
Apatite		.	0.67
Pyrite	......	......	0.50
Calcite	1.10	0.70	1.10
Water	4.23	6.37	4.53
Totals	100.09	99.90	101.41

Microscopically, the diabases are composed of plagioclase and augite, or minerals formed from them, and accessory leucoxene. Fresh specimens are comparatively rare. Table III gives the mineral composition (mode) of a typical fresh diabase (1), altered diabase (2), and a schistose dyke (3). The feldspar is commonly oligoclase, less commonly andesine or albite. It is normally clouded, with the exception of some clear untwinned albite. The pyroxene, which may be fresh, is augite with an approximate composition of $Ca_{42}Mg_{42}Fe_{16}$, determined by Y-index and 2V. The augite is normally gradationally zoned, but the variation in composition is not great. Where the pyroxene is altered, it has been replaced either by a chlorite that shows anomalous blue interference colours or, less commonly, by a fibrous amphibole. Leucoxene usually has a skeletal habit and an internal rhombohedral pattern after ilmenite and an iron oxide exsolution product. Small laths of plagioclase may be included within leucoxene grains. Calcite is invariably present in small amounts and clinozoisite and epidote are rare.

The diabasic texture may be developed in different degree or manner. The normal type of diabase has plagioclase laths about 2 by 0.5 millimetres enclosed in ophitic augite grains about 3 millimetres in diameter. A less common type has euhedral though poikilitic grains of augite (average size 1.2 x 0.7 mm.) in a matrix of plagioclase laths (1 x 0.3 mm.) and leucoxene.

Table IV.—Chemical Analyses of Mount Murray Diabases and Related Rocks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
SiO_2	50.30	50.54	47.28	45.96	48.52	53.42	51.22
TiO_2	1.50	1.06	1.06	2.56	1.54	0.70	3.32
Al_2O_3	14.26	11.10	19.71	14.03	14.78	14.12	13.66
Fe_2O_3	1.50	3.54	3.82	1.44	2.58	0.15	2.84
FeO	8.73	6.58	8.03	10.08	8.36	7.26	9.20
MnO	0.20	0.22	0.16	0.19	0.19	0.13	0.25
MgO	6.94	11.67	3.59	8.72	7.73	7.12	4.55
CaO	8.22	5.18	5.96	5.88	6.31	8.08	6.89
Na_2O	3.50	3.02	4.81	3.07	3.60	4.47	4.93
K_2O	0.13	0.10	0.34	1.65	0.56	0.63	0.75
H_2O+	3.94	5.08	3.85	5.04	4.48	2.53	} 1.88
H_2O-	0.29	1.29	0.50	0.35	0.61	0.42	}
P_2O_5	0.14	0.16	0.27	0.31	0.22	0.03	0.29
CO_2	0.50	0.32	0.50	0.54	0.46	0.39	0.94
BaO	Trace	Trace	Trace	0.44	0.11	——	——
Rest	——	——	0.26	——	0.06	0.41	——
Totals	100.15	99.98	100.14	100.26	100.11	99.86	100.72

(1) Spilitic diabase, from a sill of the Mount Murray intrusions on Beehive Mountain, Antler Creek area.
(2) Altered spilitic diabase, from a sill of the Mount Murray intrusions near Mount Greenberry, Antler Creek area.
(3) Schistose altered diabase, from a dyke of the Mount Murray intrusions at mouth of Lowhee Creek, Antler Creek area.
(4) Greenstone flow of the Antler formation, Mount Waverly, Antler Creek area. 1 to 4 by Analytical and Assay Branch, Department of Mines, Victoria, B.C.; Chief Analyst, G. C. B. Cave.
(5) Average of 1 to 4.
(6) Greenstone, Ladner slate belt of Cache Creek group, Coquihalla area (C. E. Cairnes, Geol. Surv., Canada, Mem. 139, p. 34).
(7) Average spilite, 19 analyses (N. Sundius, Geol. Mag., Vol. 67, p. 9, 1930).

Chemical analyses of three Mount Murray intrusive rocks are shown in Table IV. These specimens are:—

(1) Spilitic diabase, from a sill on Beehive Mountain.
(2) Altered spilitic diabase from a sill near Mount Greenberry.
(3) Schistose altered diabase from a dyke at the mouth of Lowhee Creek.

The mineral composition (mode) and calculated norms of these specimens are shown in Table III. For comparison, an analysis of an extrusive rock from the Antler formation (4) is included in Table IV. Because the extrusive and intrusive rocks are probably related the four analyses have been averaged (5); this average may be compared with a greenstone from Cache Creek rocks of the Coquihalla area (6) and an average spilite (7).

The *minor types* include:—

1. Quartz-feldspar porphyry is found in one sill on the lower slopes of Mount Murray in the Antler formation. Highly sericitized, euhedral albite-oligoclase phenocrysts form about 15 per cent and embayed quartz phenocrysts about 10 per cent of the rock. Some of the quartz grains show incipient recrystallization to fine quartz. The matrix is fine-grained and highly sericitic and in many places is replaced by a fibrous cherty quartz. Where the matrix has been replaced, fine chert veinlets are common. In several instances these veinlets are bridged by phenocrysts which show, in the plane of the veinlet, bands of strain and incipient recrystallization.

2. Inclusion-filled basic aphanitic dykes, which resemble flow rather than intrusive rock, are composed of greenstone and contain limestone inclusions. A dyke on Waverly Mountain is at least 6,000 feet long and as great as 400 feet thick. Rounded to platy fragments of limestone as much as 6 inches in diameter are aligned within it. Where there are no limestone fragments, calcite is commonly an integral part of the rock or forms amygdules. Microscopically, the dykes consist of patches of chlorite and microcrystalline epidote in a semi-opaque cryptocrystalline groundmass and resemble some flows of the Slide Mountain group.

3. Small basic dykes which intrude the Cariboo group may be related to the diabasic rocks but have a different fabric and somewhat different composition. Typical small

dykes are found on Wolf Creek, Bald Mountain, and Williams Creek. Microscopically, they are composed of:—

	Per Cent
Green hornblende or chlorite alteration	30–40
Plagioclase	40–60
Quartz	1–7
Iron ores	2–5
Calcite	5–10

Plagioclase phenocrysts, which form not more than 10 per cent of the rock, are commonly highly sericitized. They are zoned from labradorite cores to andesine rims. Hornblende is rarely a phenocryst. Quartz is distributed erratically and only as large embayed phenocrysts which may be accidentally included grains from the quartzites.

4. Small lamprophyre dykes are found throughout the southern part of the area. They are finely porphyritic black rocks which commonly weather to a granular sand. They are all biotite-augite lamprophyres.

Microscopically, the lamprophyres are composed of phenocrysts of augite and biotite in a matrix of the same minerals with plagioclase, hornblende, calcite, and magnetite. Olivine phenocrysts are rare. A typical specimen has the following mineral composition:—

	Volume (Per Cent)
Augite ($Ca_{45}Mg_{45}Fe_{10}$)	14.4
Plagioclase (An_{60})	48.2
Biotite	27.0
Amphibole	2.4
Iron ores	7.0
Calcite	1.0

On Roundtop Mountain a lamprophyre dyke occupies a fault with a shift of several hundred feet, but the dyke is completely unsheared. The fault cuts a diabasic dyke, and it thus appears that the lamprophyre dykes are younger than the Mount Murray diabases.

Mode of Origin.—The chemical analyses in Table IV show the similarity between Mount Murray diabase sills and dykes and Slide Mountain volcanic flows and confirms the evidence of fabric and mineralogy. All analyses are too high in soda and low in lime and potash to be true basalts, but all are too high in magnesia and low in soda to be true spilites. They are spilitic basalts and diabases.

The similarity between sills and flows and their association leads to the conclusion that they are of similar age. Hence the Mount Murray intrusions are probably Carboniferous rather than Jurassic as proposed by Johnston and Uglow (1926, p. 25). The inclusion-filled aphanitic greenstone dykes probably were intruded contemporaneously with the flows and may represent feeding conduits. Intrusion of the diabase sills may have been somewhat later than the flows, or some of the lower sills may have been contemporaneous with the later (upper) flows.

CHAPTER IV.—STRUCTURAL GEOLOGY

The structure of the Antler Creek area is complex. A great difference in manner and intensity of folding in the Cariboo and Slide Mountain groups has led to separate treatment in this chapter. The Cariboo group has been closely compressed into northwesterly trending complex folds which are overturned toward the southwest in the Antler Creek area. A regional secondary foliation is developed in the Cariboo group essentially parallel with axial planes of folds, striking northwestward and dipping northeastward. The Cariboo group has been much more strongly deformed than the Slide Mountain group, and the most intense regional folding took place before deposition of the Slide Mountain group. In the Slide Mountain group the fold axes are parallel to those in the Cariboo group, but the folds are open and unaccompanied by a secondary foliation. Fold axes in both groups plunge northwestward at shallow angles.

A prominent set of faults strikes northward and dips steeply eastward. Many faults of this set are normal but the largest are transcurrent.* Faults of both types disrupt the Cariboo and Slide Mountain groups by similar amounts, proving that faulting was most active after deposition of the Slide Mountain group.

The basis for the interpretation of structure in the Antler Creek area is similar to that stated by Holland (1954, p. 26) for the Yanks Peak-Roundtop Mountain area:—

> For the most part the interpretations of structural forms must be built from numerous isolated observations. There are very few instances where exposure is so complete and an observation point so located that any major structure can be encompassed by the eye. Once the possible complex pattern of folding is appreciated, it is apparent that the fold structures can be interpreted in the field only when (*a*) exposures are adequate, (*b*) distinctive members or beds are mapped in entirety, and (*c*) dragfolds and cleavage-bedding relationships are observable in critical structural positions.

The structure of the Antler Creek area is represented on the map and cross-sections (*see* Figs. 2, 3, 8, and 9). Axes of only the largest folds are represented.

FOLDS

Cariboo Group

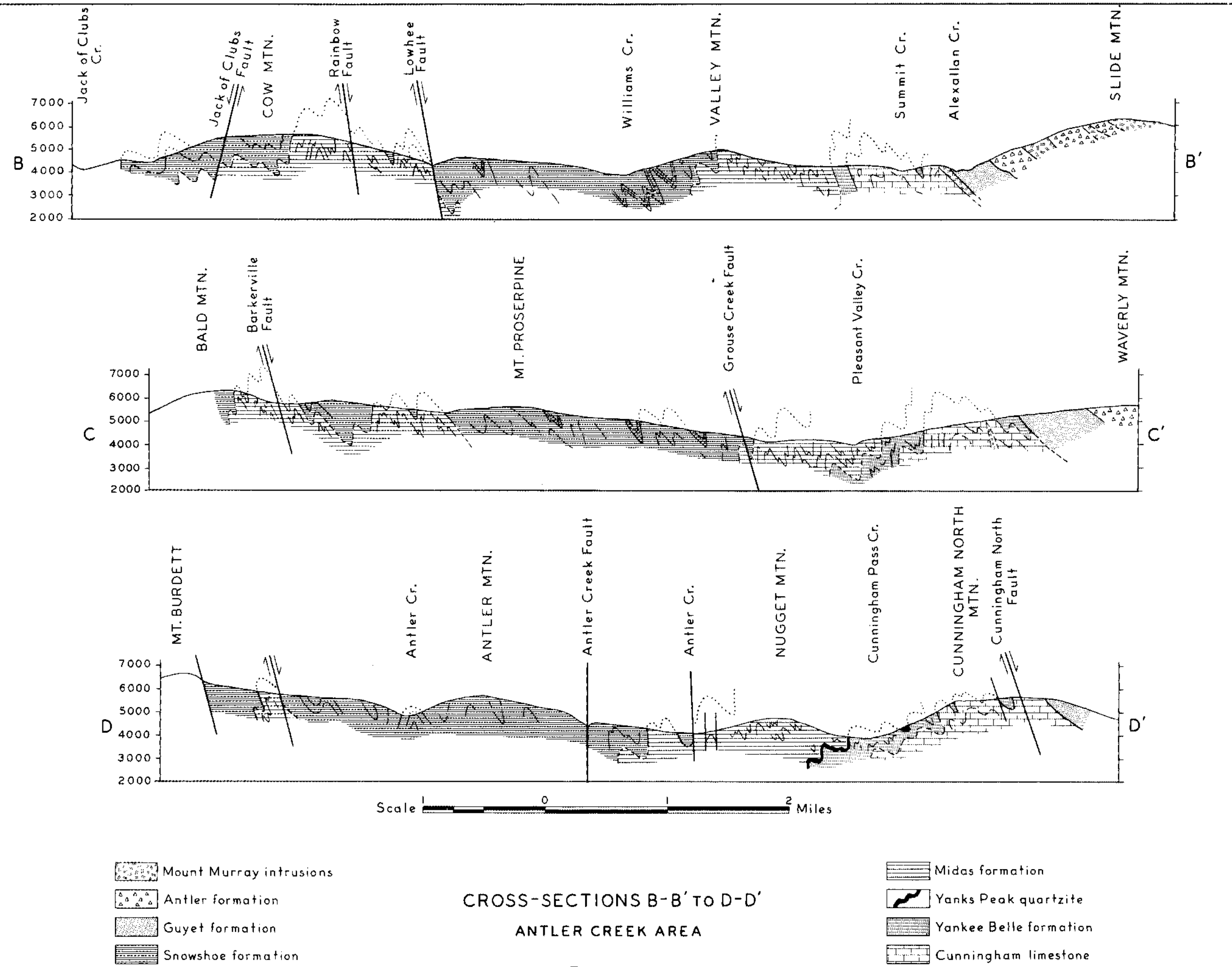
Folding in the Cariboo group is intricate. All folds are overturned toward the southwest and, with insignificant reversals, all plunge at low angles to the northwest. All folds are composite inasmuch as they are aggregates of minor folds of varying size and importance. Most folds are asymmetrical and vary in cross-section along strike. Many folds have their original stratigraphic order disrupted by shearing, rupture, and flowage. Some folds are so compressed that the actual flexure cannot be recognized.

The major folds are less compressed than the minor folds. The amplitude is approximately one-quarter of the wave-length in the major folds and equal to the wave-length in the minor folds.

In the Antler Creek area the major structure consists of a large central synclinorium—the Snowshoe synclinorium—flanked by the Cunningham and Island Mountain anticlinoria. The axes of these folds are represented in approximate position on Figure 2.

The Cunningham anticlinorium can be traced from the Roundtop Mountain area in the southeast to Eight Mile Lake in the north. It is partly overlapped by the Slide Mountain group. On the ridges running northeastward from Roundtop and Middle Mountains in this and the Yanks Peak-Roundtop Mountain map-areas the fold is characterized by opposed major dragfolds on opposite sides of the axis, repetition of lithologies, the trace of a marker bed (Yanks Peak quartzite) throughout much of the fold, and " tops " determination by cross-bedding in the Midas banded grey micaceous siltstone. Similar but less abundant evidence can be found on Waverly Mountain and Summit Creek.

* Transcurrent faults are those with strike-slip movement.



CROSS-SECTIONS B-B′ TO D-D′

ANTLER CREEK AREA

Figure 9

The digitation of the major folding is shown on the cross-sections, but the complexity of the minor folds cannot be shown. This complexity results from tearing of limbs, rupture by penetration of apices, and irregular flowage. All folds are overturned toward the southwest, and bedding in the overturned limbs dips between 80 and 65 degrees northeast.

The Island Mountain anticlinorium can be traced from Grouse Creek to Island Mountain. The core is emphasized by outcrop of the Midas formation. The fold is asymmetrical with a relatively gentle northeastern limb, a fairly flat crestal zone, and a steep, overturned southwestern limb. Much of the fold is intensely dragfolded even in the flat crestal zone. On Mount Proserpine and Williams Creek, and on Island Mountain, opposed dragfolds on either side of the axis can be found adjacent to the contact of the Midas and Snowshoe formations. Good crestal sections with relatively flat-lying Midas formation overlain by Snowshoe formation can be seen on upper Mink Gulch and Bald Mountain and on Island Mountain. Some details of the anticlinorium are given on page 53 of this chapter and in many of the property descriptions, particularly the Westport and Warspite.

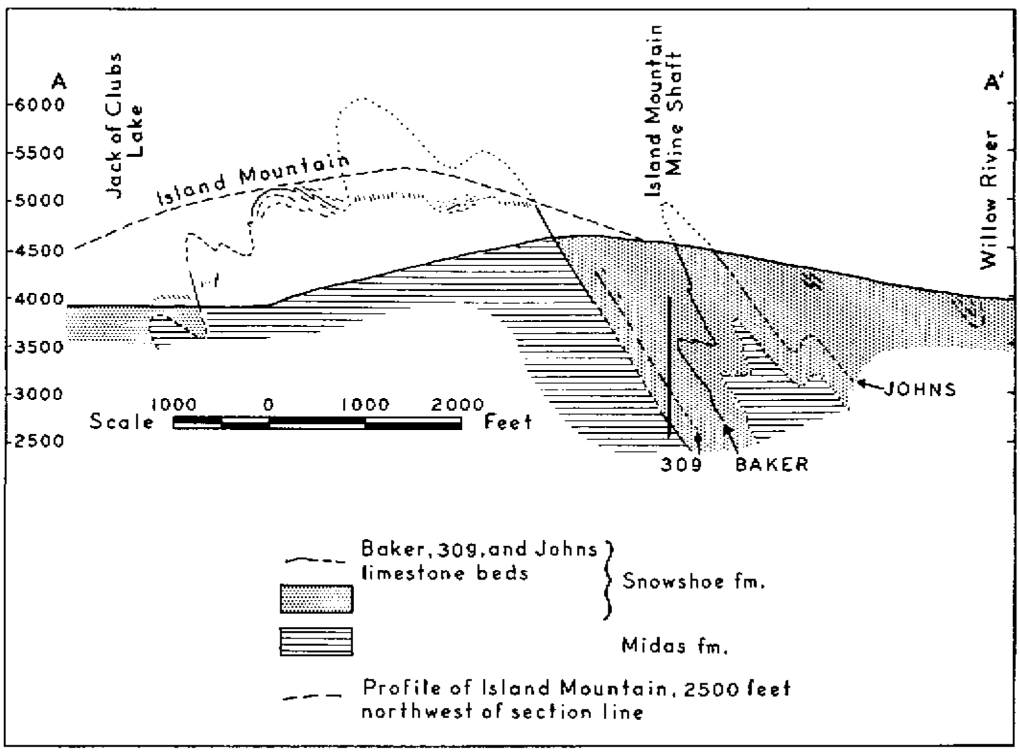


Figure 8. Cross-section A-A', Island Mountain, Antler Creek area.

The Snowshoe synclinorium extends from the Snowshoe Plateau in the Yanks Peak-Roundtop area to the Willow River in the northwestern part of the Antler Creek area. The axis is closest to the most upright or northeastern limb. The trough is filled with Snowshoe formation compressed into a great many minor complex folds, but for the most part these are poorly exposed so that relatively little is known of structural detail. The lesser folds descend in a series from both anticlinoria toward the axis of the synclinorium. The distance between crests of the two anticlinoria is more than 4 miles.

All folds in the Antler Creek area are overturned to the southwest with axial planes dipping at 45 to 80 degrees to the northeast. Just southwest of the map-area the direction of overturning changes abruptly to the northeast along the Lightning Creek axis (*see* Chapter V).

All folds plunge northwestward at small angles, averaging 7 to 10 degrees but locally as great as 25 degrees. Reversals of plunge are insignificant. The northwesterly plunge is a regional feature that extends well beyond the map-area. The plunge of folds is closely compensated by northerly striking, easterly dipping faults which repeatedly lift the plunging strata. The plunge is a younger feature than the folding and may have developed in conjunction with the normal component of faulting.

Individual folds vary greatly in shape; some are isoclinal, others are digitate or asymmetric with extreme thinning on one limb, and still others are relatively open with planar limbs diverging at 40 to 60 degrees. The illustrations (Plates VI (B), VII, and VIII; and Figures 10, 18, and 21) show some of the diversity among the smaller folds. Certain localities seem to have been focal points of intense deformation, but much of the variation in tightness and complexity is the result of differences in primary physical character of the rocks and thickness of beds. In general the more argillaceous rocks are the most closely folded, but the greatest complexities are found in the interbedded arenaceous and argillaceous rocks. Not uncommonly minor arenaceous beds in phyllite have been subjected to kneading, shearing, and irregular flowage, so that they are completely disrupted. The folds in more massive rocks are generally stratiform and may be considered to control the folds in the less massive rocks.

Different formations of the Cariboo group tend to have different styles of folding. In the Cunningham limestone, folds are commonly fairly simple with sharp flexures and planar limbs; however, the upper strata, which contain laminæ of phyllite, have been subject to intense small-scale dragfolding, crenulation, and rarely to flowage folds. In the Yankee Belle formation, folds are particularly complex because the formation is a heterogeneous mixture of argillaceous and arenaceous strata, and is contained between more massive neighbouring formations, the Cunningham limestone and Yanks Peak quartzite. The latter formation is massive and homogeneous, so that the larger folds in it are compressed but are moderately simple (*see* Holland, 1954, Plate VIII (A) and (B)), and folds with an amplitude less than the thickness of the formation are not compressed. The Midas formation as a whole is composed of fine-grained rocks and is normally compressed into isoclinal folds (*see* Plate VII (A)), but in parts that are composed dominantly of homogeneous, poorly bedded metasiltstone it is more simply folded. The Snowshoe formation is the most heterogeneous of the group, and for that reason the effects of deformation in it are the most complex and varied. In the Snowshoe formation, asymmetrical folds with irregularly thinned limbs are the rule (*see* Plates VII (B) and VIII (A)), but some of the larger folds are fairly regular close folds with sharp crests and planar limbs.

Folds vary in shape longitudinally. One of the clearest illustrations of change in shape is seen on Roundtop Mountain just east of the cairn, where the Yanks Peak quartzite is folded in a syncline (*see* Fig. 10). A subsidiary fold within the syncline is seen on the southeastern slope, but is not seen on the northwestern slope. The distance between exposures is of about the same order as the amplitude of the lesser fold on the southeastern slope. Much information on the shape of folds is available at the Island Mountain mine, where the Baker limestone beds of the Snowshoe formation are well explored. The limestone occurs in one major and many minor dragfolds that vary greatly in shape along strike (*see* Fig. 21).

The rocks of the Cariboo group have been folded at least twice. They were intensely folded before the Slide Mountain group was laid down and were later affected by the Slide Mountain deformation. It is rarely possible to identify second-generation folds in the Cariboo group, partly because the later deformation was less intense than the earlier and partly because the Slide Mountain and Cariboo folds are parallel. Holland (1954, p. 35) describes folded cleavage in the Yanks Peak area, which he relates to a second deformation. Benedict (1945, pp. 758–761) interpreted certain warpings at Island

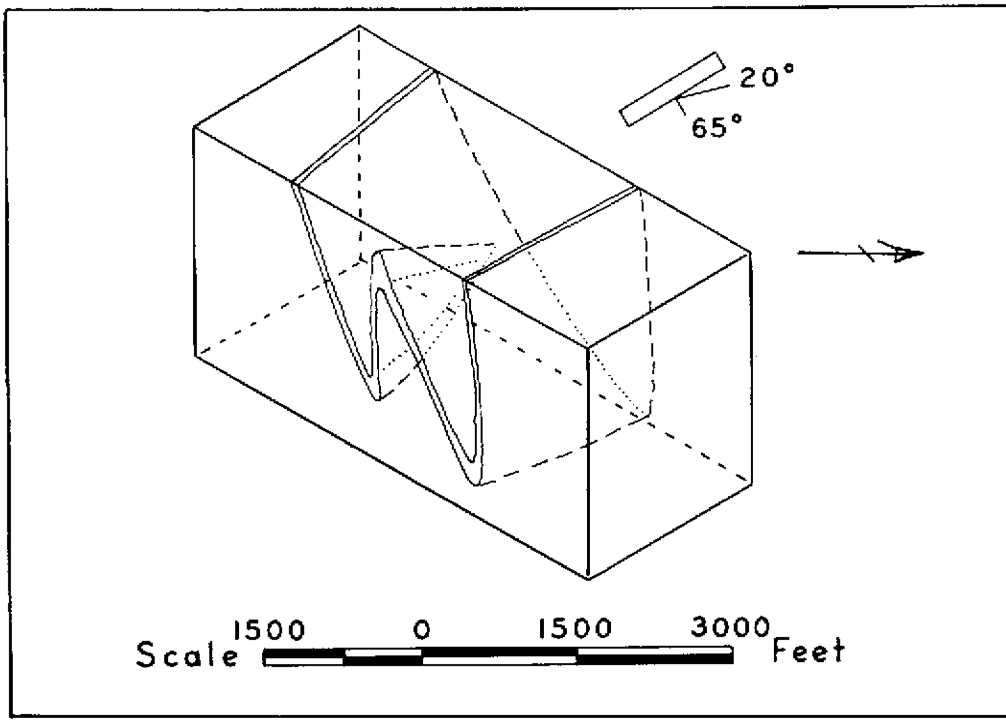


Figure 10. Longitudinal change of shape of a syncline at Roundtop Mountain.

Mountain mine as signifying second-generation folding. However, in general, folded cleavage is not common in the Antler Creek area, and those examples seen by the writer have steeply plunging axes and are clearly related to faulting. Possibly the main effect in the Cariboo group of later deformation was to intensify earlier structures.

*Secondary Foliation**

Schistosity* and cleavage* are well developed in most Cariboo group rocks in the area. These related features are developed in different degrees, depending primarily on intensity of folding and mineral composition. The characteristic rocks of the Cariboo group are phyllite and micaceous quartzite.

Secondary foliation is normally more apparent than bedding, and in a majority of exposures only the secondary foliation is manifest. In exposures exhibiting pronounced secondary foliation, bedding can commonly be found to be essentially parallel to schistosity. Other exposures will show, either readily or on detailed examination, different orientations for bedding and schistosity, and these exposures are vital in structural interpretation. Unfortunately in probably the majority of exposures, foliation alone is evident. In such cases it cannot be assumed with confidence that bedding is parallel to schistosity.

For the most part the secondary foliation is oriented subparallel to the axial plane of folds and, because these folds are tightly compressed, also subparallel to bedding in the limbs. Less commonly the schistosity follows bedding around the crests and troughs of folds and hence is called bedding schistosity. In isolated exposures it is impossible to distinguish axial plane from bedding schistosity unless the exposure happens to be at an axial zone.

* Schistosity and cleavage are related secondary foliations, the former being a matter of crystal size and degree of mineral orientation, and the latter the ability to split. In this bulletin, foliation without a qualifying adjective signifies cleavage, schistosity, or bedding where these are not readily distinguishable from one another.

Bedding schistosity is restricted to a particular rock assemblage, interbedded micaceous quartzites and phyllites. However, in a majority of folds in these rocks where a distinction could be made, the normal axial-plane foliation was present. In folds with bedding schistosity it is apparent that interbed slip and shearing have been of major importance because the micaceous quartzites are of flaser type and the phyllites are minutely crenulated in tiny dragfolds related to the general movement picture. Overfolding of these crenulations in the bedding schistosity has produced a second cleavage at about 70 degrees to bedding in the limbs. These relations are illustrated diagrammatically in Figure 11. The intersection of all foliations is parallel to the fold axes, and hence a *b*-lineation.

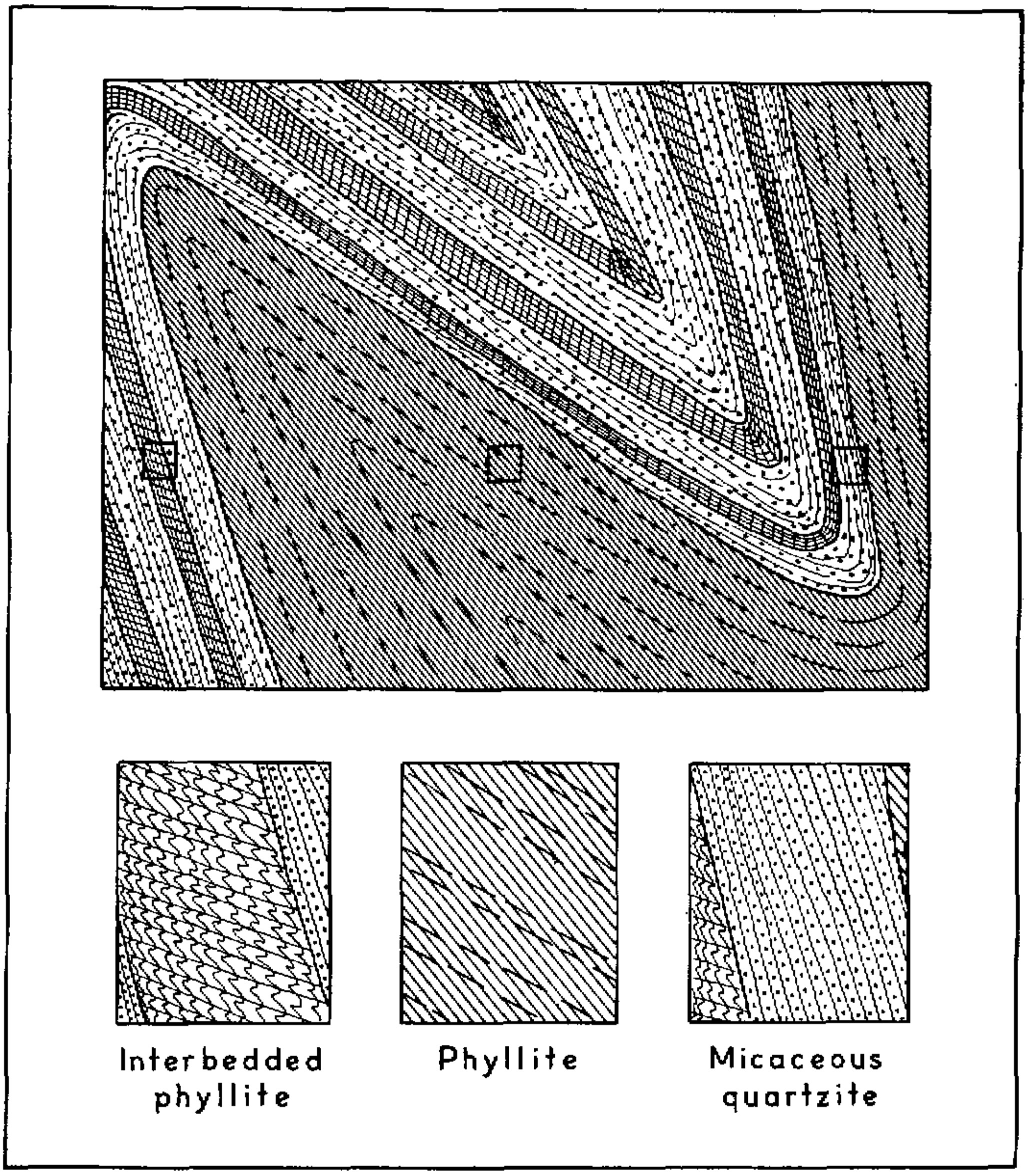


Figure 11. Axial plane and bedding schistosity in relationship to bedding in part of the Snowshoe formation.

The bedding schistosity appears to have originated during the same period of folding as that of the normal axial-plane foliation. It does not seem to be a second or folded cleavage; on the contrary, its restriction to a certain rock assemblage suggests it results in response to a particular set of physical conditions in which interbed slippage was of major importance. Tightly compressed folding probably could be accomplished without the development of axial-plane foliation.

Various rock types show secondary foliation in varying degree. The argillaceous rocks of Yankee Belle, Midas, and Snowshoe formations show the most highly developed cleavage and schistosity (*see* Plates IV (B) and VII (A)). The arenaceous rocks of Yankee Belle and Snowshoe formations have a well-developed schistosity but not invariably a good cleavage (*see* Plates V (B), VI (B), and VII (B)). The pure Yanks Peak quartzite has locally a widely spaced cleavage (*see* Plate V (A)). The Cunningham limestone is not normally fissile but may be at sharply folded crests. Where it is fissile there is commonly a darkening of colour along the cleavage that might be interpreted as bedding were it not seen to cross argillaceous bedding laminæ.

The degree of schistosity and cleavage is related to the intensity of folding. This is particularly noticeable in the argillaceous rocks in which fissility increases markedly on approaching a locus of intense folding.

Microscopic Fabric

The Cariboo rocks have a fabric with two main characteristics—a marked dimensional orientation or schistosity and a flattened fabric with *a* and *b* axes approximately equal. The dimensional orientation is most closely followed by the micaceous minerals, which only diverge from parallelism to wrap around large quartz and feldspar grains and lenticles. Quartz, feldspar, and carbonate minerals, even in pure quartzites and some limestones, tend to be flattened to a lenticular shape in the foliation. This tendency is slight in pure quartzites, moderate in some thin limestone members, and moderate to extreme in granule conglomerates and micaceous quartzites. The extreme development in the clastic rocks has a flaser or mylonitic appearance (*see* Plate IX (C)).

The flaser quartzite is widespread, is not associated with any known faults, and is judged to result from folding alone. It is notable that the flaser quartzite is commonly interbedded with phyllites in strata that presumably have been subject to large interbed movements.

The microfabric of Cariboo rocks is somewhat different than that of many strongly deformed regions. Highly folded strata in most regions have a texture in which detrital grains are extended as prolate spheroids in the *b* axis or, less commonly, in the *a* axis, but in the Cariboo group detrital grains are flattened to oblate spheroids in the *ab*-plane. This indicates a dilation of the whole foliation plane, which is commonly the plane of bedding as well as schistosity. Detailed description of the microscopic fabric is included in Appendix A.

Joints

The Cariboo rocks have one joint set which is universally prominent, the AC-joints.* Other joints are developed locally but are not of great importance. The AC-joints are developed almost equally well in all rocks. They are as a rule a few tens of feet apart and may be traced for about the same distance, rarely 100 feet. In some instances they are as close as a foot apart. The AC-joints are of great importance in the mine area, where they are vein-filled and have acted as conduits for ore-forming fluids. They are more fully described in Chapters VI and VII.

Slide Mountain Group

Folding in the Slide Mountain group has everywhere produced relatively simple, upright, and open structures. The group in the Antler Creek area forms the southwestern limb of a major syncline that is one of a series forming the Slide Mountain structural

* Extension joints normal to the fold axes. *See* Turner and Verhoogen, 1951, pp. 532, 535–536.

trough or synclinorium. The axis of the major syncline is just northeast of the map-area. Bedding in it is not over 45 degrees except along the southwestern margin where the Guyet conglomerate dips as steeply as 60 degrees. Minor compressional folds are open, with the exception of one relatively close fold on Mount Guyet. All folds plunge at small angles to the northwest. Secondary foliation is generally absent and microscopic texture generally undeformed. Folds in the Slide Mountain group thus contrast strongly with those of the Cariboo group and there is a marked structural discordance between the two groups.

Joints in the group are not prominent, and the only clearly recognizable set is that of the AC-joints. These are poorly developed although widely distributed.

Cleavage in the Slide Mountain group is only local. In some of the Antler argillites a fracture cleavage indicates normal interbed slip. Cleavage in some exposures in the base of the Guyet formation may be the result of shearing at the base of the group.

Several types of minor folds are found in the Slide Mountain group that clearly originated in a different manner than the compressional folds. Slump structures are discussed on page 37. Minor fan folds with axes plunging down dip in thin-bedded cherts are believed to have been caused by side thrusting by sills. Chert rafts in diabase sills are commonly concordant with near-by bedding and with the margins of the sills, but some rafts are found in swirled and contorted shapes indicative of flowage folds.

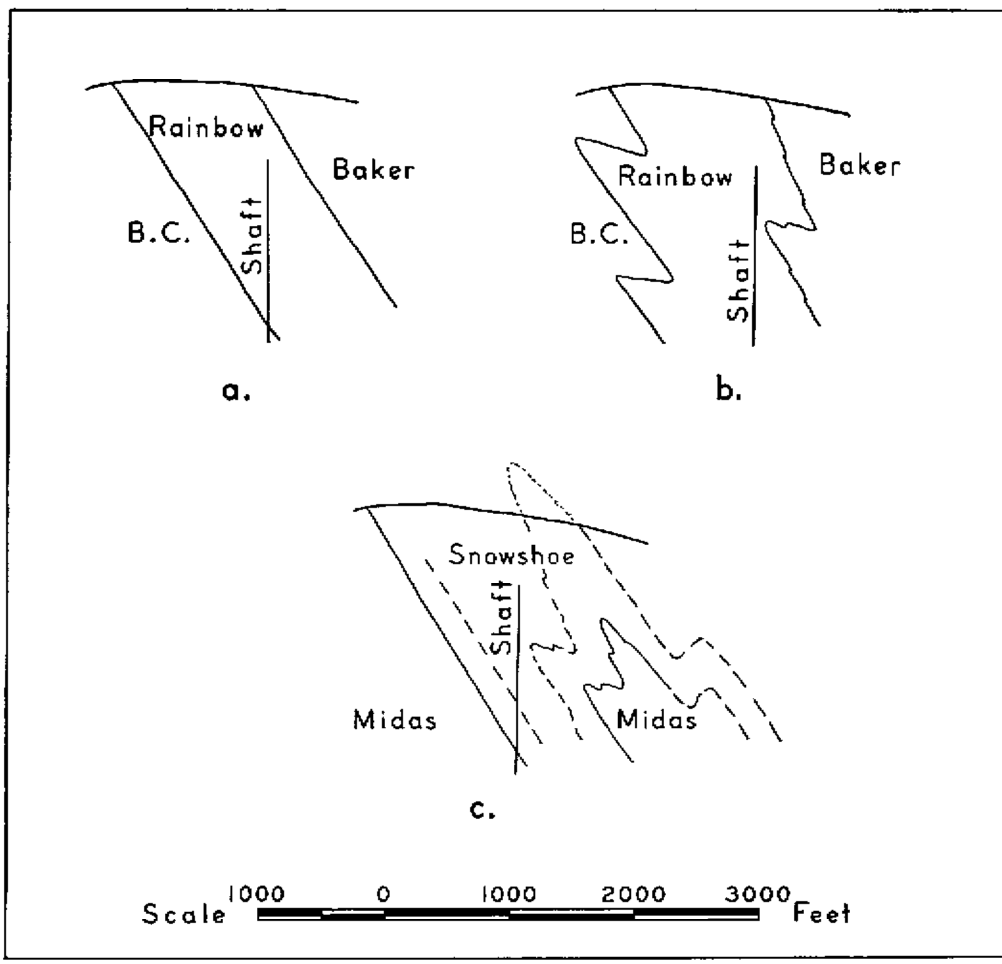


Figure 12. Interpretations of the structure at Island Mountain mine according to (*a*) Hanson, (*b*) Benedict, (*c*) the writer.

FOLD STRUCTURES OF THE WELLS MINING CAMP

The fold structures of the Wells mining camp are asymmetrical and complex and cannot be mapped without interpretation. The main structures in the camp, which is entirely within the Cariboo group, are so important that they are discussed here as a background for property description. Figure 12 diagrams the interpretations of the structure and stratigraphy at the Island Mountain mine by (*a*) Hanson, (*b*) Benedict, and (*c*) the writer. Figure 8 shows a more extensive section to scale. All sections are drawn normal to the strike through the shaft at Island Mountain mine, looking northwestward.

The first concept, that of Hanson (1935), was formed at an early stage in the underground development. He envisaged an uncomplicated section facing and dipping northeastward.

Later Benedict recognized overturned folding. He mapped a relatively large dragfold in the Island Mountain mine (the mine dragfold) that is well outlined by a thin limestone and phyllite member (Baker limestone beds of the Snowshoe formation). He concluded (Benedict, 1945, p. 761):—

> While the Baker is indubitably resting on the Rainbow, the folding is of such a nature . . . that the simplest interpretation is that the next larger anticline is to the northeast of the mine and that the beds are overturned, the Rainbow being younger than the Baker though lying below it.

The writer, with the benefit of regional study, believes the structure to be even more complex than did Benedict. The Island Mountain mine is in overturned folds on the northeastern flank of the Island Mountain anticlinorium. Some of these folds are readily mapped, whereas for others the evidence may consist simply of the fact that there should not be two anticlines without a syncline between them.

The writer has mapped the Island Mountain anticlinorium from Grouse Creek to Island Mountain. On the northeastern flank of this structure there is an attenuated isoclinal syncline, called the Sanders syncline, which is in all probability highly asymmetrical. On the northeast limb of the syncline is the mine dragfold and, beyond, a middle-sized anticline.

The Sanders syncline is an interpretation inasmuch as nowhere can the actual fold be seen nor can satisfactory evidence of the position of the axial plane be found. On the other hand, there is no doubt that the mine dragfold indicates a syncline to the southwest that lies between the mine dragfold and the Island Mountain anticlinorium. Suggestive evidence of the Sanders syncline is provided by opposed small dragfolds in the Cariboo Gold Quartz mine (*see* pp. 77–78). Lack of direct evidence of isoclinal folding is not uncommon in rocks without marker beds such as limestone. Good examples of such a condition are present in Island Mountain mine, where folds that are clearly outlined by limestone cannot be detected in adjacent micaceous quartzites (*see* Plate VIII (B), Fig. 21, and p. 84).

If the Sanders syncline does not exist, then the mine dragfold must be the result of interbed movement in a direction opposite to that which is normal during stratiform folding. There is no evidence of abnormal folding in the region.

The anticline indicated by the mine dragfold to lie to the northeast is small compared to the Island Mountain anticlinorium, because no Midas formation is exposed at the surface. This anticline is one of the series of folds descending from Island Mountain anticlinorium to the Snowshoe synclinorium. Dragfolds on Mosquito Creek above Red Gulch are opposed to the mine dragfold and indicate that they are on the other side of the anticlinal axis. An anticline of moderate size observed on Lowhee Creek is probably the same one.

FAULTS

Faults are common in the Antler Creek area. The pattern of principal faults is relatively simple and the orientation quite restricted (*see* Fig. 13). The major faults all strike within the northeast quadrant; most strike northward but a few strike eastward. Numerous small faults are oriented subparallel to the foliation in the Cariboo group. Most of the northerly faults are essentially normal faults that have some strike-slip movement, but others are essentially transcurrent.

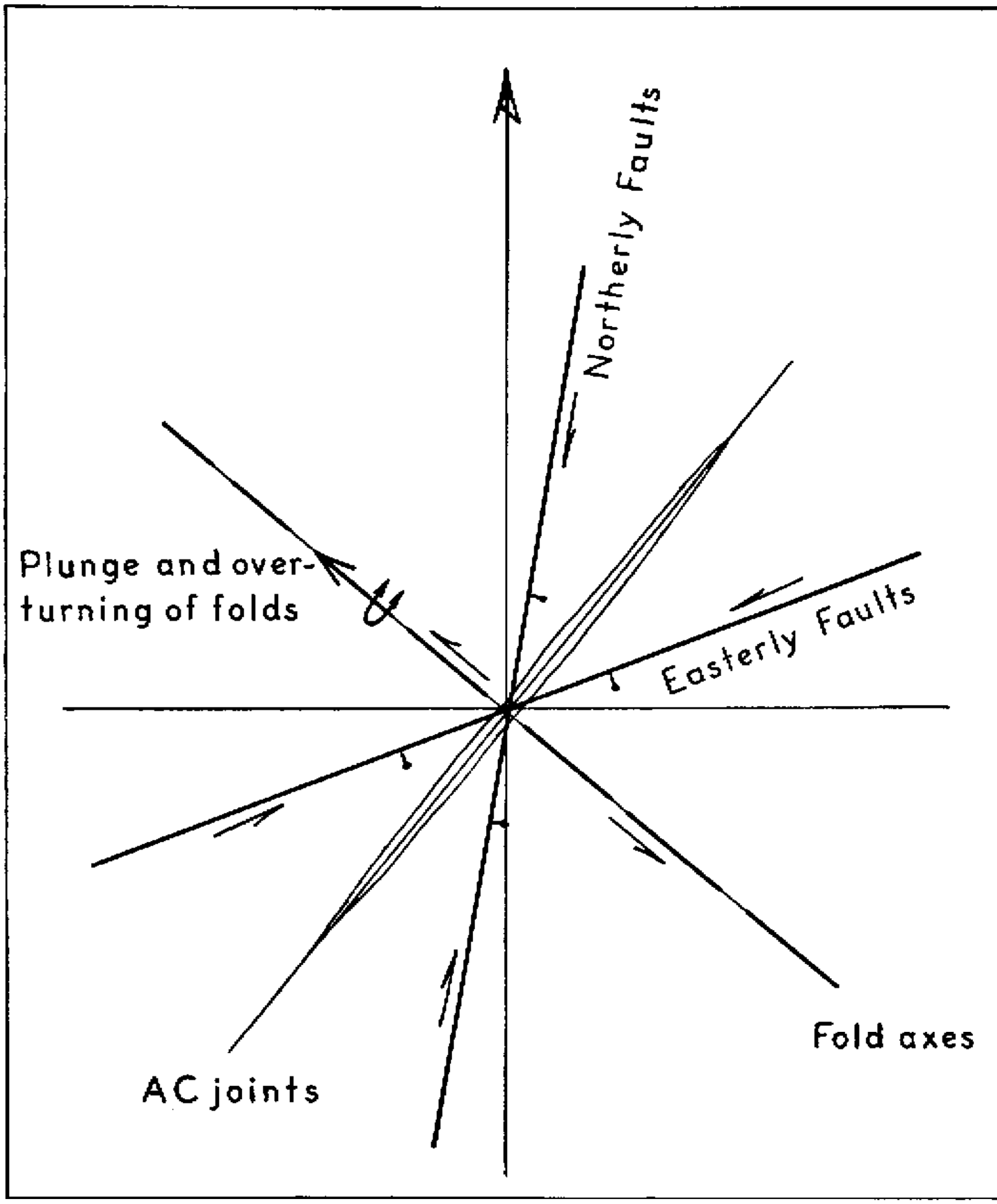


Figure 13. Orientation of faults, folds, and joints, Antler Creek area.

Faulting appears to be considerably younger than the Cariboo folding. The large faults disrupt the Slide Mountain group and Mount Murray intrusions as much as the Cariboo group.

The northerly trending faults strike between north and north 20 degrees east and dip steeply eastward. Most are essentially normal faults which have some strike-slip. Other faults, no different in orientation or surface expression, have been subject to large strike-slip and much less dip-slip, and hence are essentially transcurrent faults. In general both types of faults produce right-hand horizontal separation. This separation could result from normal dip-slip alone because the strata dip northeastward, but nearly horizontal slickensides in the normal faults exposed in the mines indicate a horizontal component of movement. On the only fault in which the total movement has been accurately determined, the Aurum fault, strike-slip exceeds dip-slip. The transcurrent northerly faults have been subject to normal dip-slip as well as right-hand strike-slip, but the former is negligible in comparison. On the Antler fault the strike-slip is about 2 miles, but the dip-slip is less than 1,000 feet. There is no detectable difference in the amount of offset in the Slide Mountain and Cariboo groups. On the Antler fault, the largest in the area, the offset in the two groups appears to be identical.

The normal component of movement on the faults almost exactly compensates for the northwesterly plunge of folds in both Slide Mountain and Cariboo groups. Were not the folds repeatedly dropped by the faults, the different stratigraphic units would have limited exposure along the axis of a fold. For example, without faulting the limestone exposed in the Cunningham anticlinorium at Roundtop Mountain would extend only to Cunningham North Mountain whereas it does continue past Eight Mile Lake.

The easterly striking faults are smaller and less numerous than the northerly. They strike north 55 to 75 degrees east and dip steeply southward. They commonly have a small left-hand separation and may have some normal movement. In general they seem to be complementary to the transcurrent component of the northerly faults.

Faults of small displacement subparallel to the foliation, " bedded " faults, are common and are widely distributed. They strike approximately north 45 to 60 degrees west and dip 45 to 60 degrees northeastward. They are numerous in the mines but are rarely observed on the surface. There is some indication that they are most numerous in areas of large plunge. In some instances the bedded faults are " horsetails " from the northerly faults. More commonly they extend between adjacent northerly faults and cut the fault block into plates which have adjusted separately, the upper or northeastern plate having moved down the plunge.

The gold pyrite lodes of the area are directly related to the fault and fracture pattern. In the Wells camp the veins occur in clusters localized along the pre-vein northerly faults. Small easterly faults adjacent to the northerly faults are vein-filled (diagonal veins), as are the AC-joints (transverse veins). In contrast to the northerly and easterly faults, the AC-joints must have originated during the Cariboo folding and were accentuated by later folding and reopened during faulting. The northerly faults seem to have been the main conduits for ore-forming fluids and the AC-joints the main distribution system.

In summary, faulting was insignificant during the major folding of the Cariboo group and was not important until after the folding of the Slide Mountain group. The major faults, whether essentially normal or essentially transcurrent, disrupted the Slide Mountain group and Mount Murray sills as much as the Cariboo group. Probably the faults were initially normal faults and were subject to later transcurrent movement that was channelled dominantly along the larger of the existing normal faults.

Descriptions of Faults

The following descriptions of the major known faults start with the most easterly. The faults are shown on Figures 2 and 3 and those of the Wells mining camp also on Figure 16.

The Cunningham North faults are known chiefly from the offset of Cunningham limestone on Cunningham North Mountain. They have a vertical separation of 500 feet or greater and an apparent horizontal separation of 1,000 to 2,000 feet. They are probably responsible for the offset of the base of the Snowshoe formation on Nugget Mountain and of the Snowshoe synclinorium axis.

The Antler fault, the largest in the map-area, is a right-hand transcurrent fault which can be traced in a straight line for 25 miles from the Swift River to Bowron Lake. All formations in the map-area are offset approximately 9,000 feet by it. The average strike is north 15 degrees east. The fault is indicated topographically in the map-area by Sawmill Flat, China Pass, and Antler Creek. On the upper Swift River the Lightning Creek Axis (*see* Chapter V) is offset about 2 miles. In the Bowron Lake-Spectacle Lakes trench the Cunningham limestone is faulted against Slide Mountain rocks. In an exposure made by hydraulic mining at the head of China Pass Creek, about 50 feet of rubbery fault gouge is seen between walls of highly shattered micaceous quartzite; the banding in the gouge strikes due north and has a vertical dip. Splayed branch faults are evident at the mouth of California Creek and on Antler Creek at McNeill and Pittman Creeks.

The Grouse Creek fault has a right-hand separation of about 800 feet. It is probably a normal fault with a dip-slip of the same order. Its slightly sinuous trace follows the deep narrow valley of the upper part of Grouse Creek and the sharp gully at the source of Canadian Creek.

The Barkerville fault is a normal fault probably of greater than a thousand feet displacement. It may have a slightly curved path as mapped, or it may be composed of several strands. Placer-mining on Williams Creek just above Mink Gulch and at Barkerville has exposed strands with as much as 2 feet of gouge. A fault exposed in the wall of the cirque on Bald Mountain may be the continuation of the Barkerville fault.

The Sirius fault zone is exposed in the Shamrock tunnel and on Stouts Gulch. It is predominantly a normal fault of large displacement and has a nearly vertical dip. Drilling has shown the vicinity of the fault to be much broken.

The Lowhee fault, the largest in the mine area, has a horizontal separation of about 1,400 feet. It is essentially a normal fault with a dip-slip of the same order as the horizontal separation. The fault has several branches. The main fault and one branch, the Lowhee split, are exposed in the Cariboo Gold Quartz mine. The main fault has an average dip of 70 degrees southeastward. Hydraulic mining in Lowhee Creek in 1955 clearly exposed the Lowhee fault at the junction with the Lowhee split. Gouge is found at two other points in Lowhee Creek, which is the topographic expression of the fault. The fault probably extends to Downey Creek.

The Rainbow fault is about one-third the size of the Lowhee fault and is exposed on the Lowhee Ditch and in the Cariboo Gold Quartz mine. It dips about 60 degrees southeastward and has a horizontal separation of 400 feet and a dip-slip of the same order.

The Jack of Clubs fault is seen in the Island Mountain mine and is the only large fault known to dip 50 to 60 degrees northwestward. It is aligned with a fault exposed on the Lowhee Ditch, and the rock distribution on both may signify a reverse movement.

The Aurum fault is known to have had both normal and strike-slip movement. In the upper levels of the Island Mountain mine the fault strikes north 20 degrees west and dips 40 degrees east. Its movement, as determined by Benedict (1945, p. 762), is 475 feet in strike-slip and 240 feet in dip-slip. In the lower levels it flattens and becomes unrecognizable. Its orientation is slightly unusual, but the direction of movement on it is south 59 degrees east, and is little different from that of movement on the majority of faults which strike north 10 to 30 degrees east.

The Mosquito fault is known from drill-holes at Island Mountain mine and from offsets at Mosquito Creek and on the southeastern face of Island Mountain. It appears to be a normal fault of moderate displacement that dips steeply eastward.

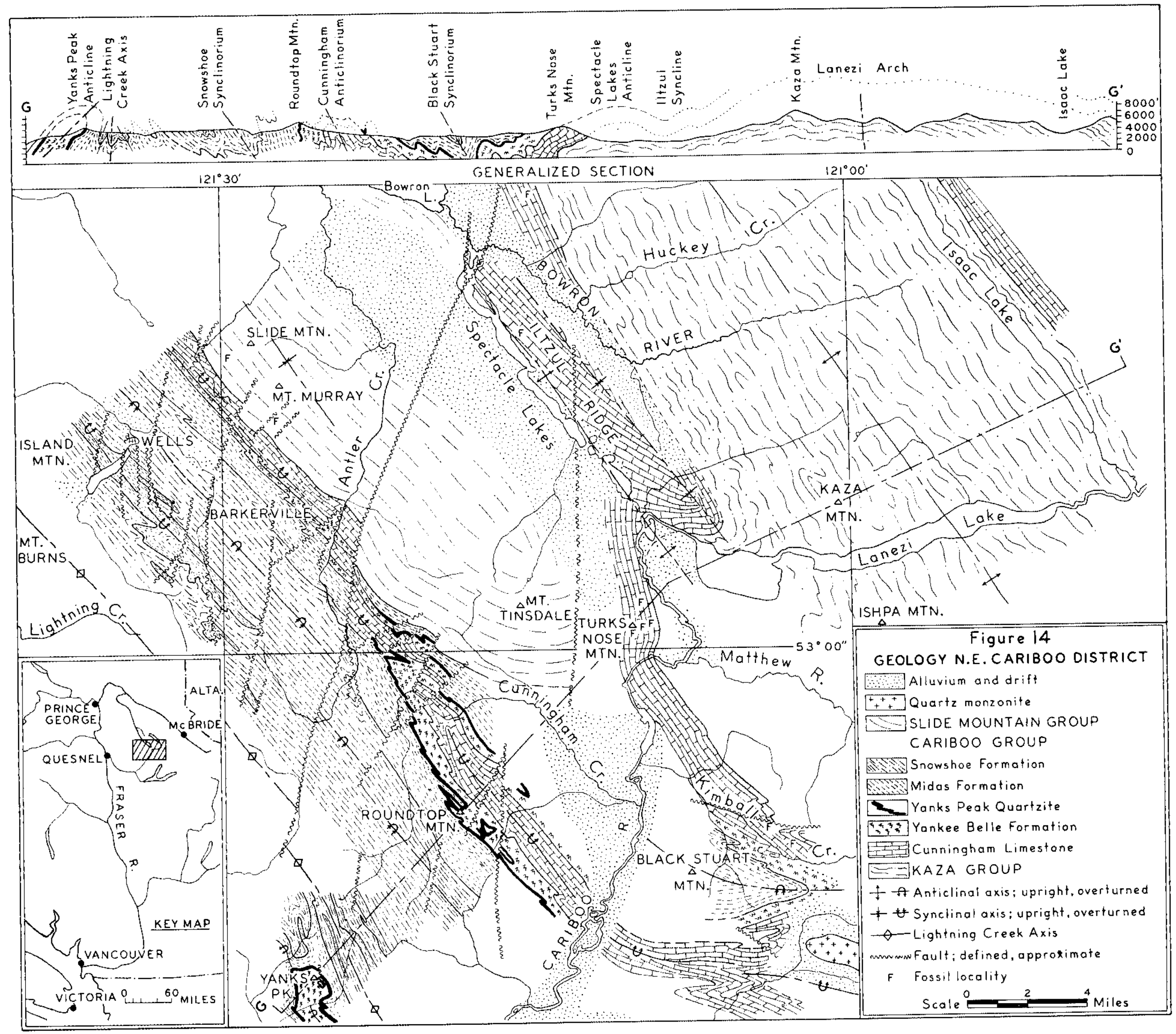


Figure 14
GEOLOGY N.E. CARIBOO DISTRICT

CHAPTER V.—REGIONAL GEOLOGY AND INTERPRETATION

This chapter discusses the regional geology of the northeastern Cariboo District and deals with a number of topics of broad regional interest. The concept of the regional geology is preliminary, and some of the ideas expressed are speculative. All matters discussed bear on problems of the geology of the Antler Creek area.

REGIONAL GEOLOGY

The geology of the Antler Creek area and the region under discussion is shown in Figure 14. It is compiled from Figure 2 and the maps of Holland and from reconnaissance to the east and southeast by the writer.

The area south of Matthew River and east of Cariboo River is part of the Little River area (Lang, 1940, Map 561A). Major changes in interpretation have been made in this area, and these must be explained in some detail because the age assigned to the Cariboo group is dependent upon them.

Lang's mapping shows a syncline which is occupied unconformably by the Slide Mountain and Cariboo groups (this is the same as the Black Stuart synclinorium of Figure 14). A major strike fault on the northeastern flank of the syncline cuts off the Slide Mountain group, and the Cariboo group rocks cannot be correlated across the fault. A small area of Cambrian strata occurs between the fault and the trough of the syncline, which strata are conformable with the Cariboo group but are not named or included with them. A thick limestone, named the Jackpot, occurs on the northeast limb of the syncline as part of the Slide Mountain group. This limestone pinches out rapidly to the southeast and does not appear on the southwest limb. Lang (1938, pp. 14–15; 1947, pp. 31–32) reported that Carboniferous or Permian "poorly preserved corals" were collected from the Jackpot formation but listed none in either publication.

The writer, on the other hand, found no Slide Mountain rocks southeast of the Cariboo River. The Black Stuart synclinorium involves only rocks of the Cariboo group and older. The Jackpot limestone is continuous in outcrop with the limestone at Turks Nose Mountain and that on Kimball ridge, from both of which localities an Early Cambrian fauna has been collected (*see* below). Officers of the Geological Survey of Canada were unable to find Lang's collection from the "Jackpot formation," and it can only be surmised that poorly preserved archæocyathids had been incorrectly identified as corals. On the southwestern limb of the Black Stuart synclinorium the thick limestone can be traced into the Cunningham limestone of the Roundtop area.

The stratigraphic section of the region shown in Figure 14 is the same as that of the Antler Creek area, augmented by the Kaza group, which conformably underlies the Cunningham limestone and is a sequence of metamorphosed clastic rocks thicker than 6,000 feet. The writer has named the Kaza group after Kaza Mountain, where it is well exposed (*see* Plate III (A)). All but the upper 1,000 feet of the group is composed of green micaceous greywacke, green schist with knots of biotite, garnet, or both, and minor schistose pebble conglomerate. The upper 1,000 feet consists of crossbedded white to brown quartzite and brown phyllite.

The Cariboo group east and southeast of the Antler Creek, Yanks Peak, and Roundtop Mountain areas is not significantly different from that within those areas. The major difference is that there is 100 to 200 feet of limestone at the top of the Yankee Belle formation. This prominently marks the plunging trough of the Black Stuart synclinorium. The Cunningham limestone is fully exposed on Turks Nose Mountain and is approximately 2,000 feet thick.

The Slide Mountain group beyond the Antler Creek area contains a higher proportion of pillow lavas and intrusive diabase than within, but otherwise it is similar.

Ten miles southwest of Yanks Peak the Cariboo group is overlain unconformably by the Quesnel River group, which is largely of Jurassic age. The contact is approximately parallel to the strike of the Cariboo group.

REGIONAL STRUCTURE

The structure of the northeastern Cariboo district is complex in detail but in overall perspective is relatively simple. The structure culminates in a broad anticlinorial arch which is flanked on the west by a descending series of tightly compressed folds of some complexity.

The folds of regional importance in the northeastern Cariboo are listed from northeast to southwest and described below. They are shown in the geological cross-section of Figure 14, with the exception of No. 7. Many of the folds of regional importance are outlined by the Cunningham limestone. All folds plunge northwestward at an average of 5 to 10 degrees with local, insignificant reversals. With the exception of the Lanezi anticlinorial arch and folds of the Lightning Creek axis, all folds are overturned, those between the arch and the axis being overturned to the southwest and those southwest of the axis being overturned to the northeast.

1. Lanezi anticlinorium.	
2. Iltzul syncline.	
3. Spectacle Lakes anticline.	
4. Black Stuart synclinorium.	
5. Cunningham anticlinorium.	Roundtop Mountain and Antler Creek areas.
6. Snowshoe synclinorium.	
7. Island Mountain anticlinorium.	
8. Lightning Creek axis.	Yanks Peak area.
9. Yanks Peak anticline.	

The culminating fold of the northeastern Cariboo district is the Lanezi anticlinorium, which trends northwestward between and parallel to Isaac Lake and Spectacle Lakes. This fold is a broad whale-backed arch over 15 miles wide on which ride a series of relatively small parallel folds. The limbs of the arch dip at 30 to 40 degrees from a wide flat central section. The fold is outlined by the outcrop of the Cunningham limestone, and the core exposes the Kaza group. Schistosity is well developed in the fine rocks of the Kaza group, less well in the coarse. It commonly dips within 10 degrees of vertical on either limb but is parallel with bedding in the central section.

The first two distinct major folds of the series descending toward the southwest are the Iltzul syncline and Spectacle Lakes anticline. Both are relatively open structures with dips rarely exceeding 45 degrees. They expose Cunningham limestone at the surface.

The plunging keel of the Black Stuart synclinorium is outlined on the ground by a thin limestone at the top of the Yankee Belle formation. The fold is overturned, with the northeast limb approximately vertical and the southwest limb dipping approximately 45 degrees northeastward. Schistosity is well developed parallel to the axial plane. At the eastern limit of mapping, the keel of the syncline plunges northwestward at 25 to 40 degrees. As the fold is traced northwestward the plunge lessens and the axis bends to the normal northwest trend. Northwest of the Cariboo River the Black Stuart synclinorium is overlain unconformably by the Slide Mountain group in a distinct and separate structural trough. The axes of these structures approximately coincide, but the intensity of folding within them differs greatly. In contrast to the Black Stuart synclinorium, in the Slide Mountain trough bedding commonly dips less than 40 degrees and axial plane cleavage is not developed.

The Cunningham anticlinorium exposes a core of Cunningham limestone about which the remainder of the Cariboo group is wrapped in a series of intricate minor folds. The typical folds are asymmetric and almost isoclinal. Axial plane cleavage is developed in almost all rocks, even in the Cunningham limestone, at the axes of tight folds. The phyllites of the group have a papery fissility and have been so kneaded that minor folds commonly lack a stratiform nature. All folds are overturned toward the southwest, and bedding in the overturned limbs dips between 80 and 65 degrees northeast.

The Snowshoe synclinorium is developed in Snowshoe micaceous quartzites, phyllites, and minor limestone. The structure is extremely asymmetrical and complex, and contains a great number of essentially isoclinal minor folds. Many folds cannot be distinguished in phyllite or micaceous quartzite, but only where there are thin interbeds of limestone. Characteristically, schistosity is well developed. Folds are overturned to the southwest with axial planes dipping on the average 70 degrees to the northeast.

The Island Mountain anticlinorium is the largest and most important of a group of anticlinal structures to the southwest of the Snowshoe synclinorium. Each fold is overturned to the southwest and tightly compressed. All contain cores of black Midas phyllite and metasiltstone.

Southwest of the Island Mountain anticlinorium is the Lightning Creek axis, one of the major structural features of the region. This feature was interpreted as "the anticlinorium of the Barkerville area" by Bowman (1889, p. 27) and by Johnston and Uglow (1926, p. 31), but the Lightning Creek axis is not a simple fold so much as a locus of change of dip of cleavage and of axial planes of folds. Cleavage and axial planes dip away from the axis on either side. Curiously, the Lightning Creek axis does not coincide with a major culminating fold structure. The axis is essentially parallel to the regional trend, yet the central fold structure changes along strike, either through change in shape of the fold or a slight divergence in trend. At Yanks Peak the central fold is a bag-shaped syncline (Holland, 1954, pp. 25–28) whereas at Stanley, 20 miles northwest of Yanks Peak, it is an anticline. The significance of the Lightning Creek axis is not clear.

The Yanks Peak anticline is the most westerly fold of the region mapped by Holland and the writer. It lies west of the Lightning Creek axis, and thus the axial plane dips westward. Yankee Belle phyllite occupies the core of this dome-like anticline, and Yanks Peak quartzite, Midas formation, and Snowshoe formation are wrapped about the structure in a succession of complex folds. The Yanks Peak quartzite has been pulled apart by severe folding, and the minor folds are tight, asymmetric, and not entirely stratiform.

The fault pattern described in Chapter IV is characteristic of the region of Figure 14 except southeast of the Cariboo River, where faults are oriented in many directions. The largest known is the Kimball fault, a high-angle thrust with a movement of 500 to 1,000 feet that cuts at a small angle across the strike of beds. This local variation in the fault pattern is possibly related to the intrusion of a near-by quartz monzonite stock.

Comparison of the Geology of the Cariboo and Kootenay Districts

The structure and stratigraphy of the northeastern Cariboo District (Cariboo Mountains and Interior Plateau) have features similar to those of the East Kootenay District (Purcell Mountains and southeastern Selkirk Mountains). The structure in both culminates in a broad anticlinorial arch which is flanked on the west by a descending series of tightly compressed folds of some complexity. The rocks in both are generally similar in type and age. The main point of difference is that the Purcell arch is much broader than the Cariboo arch, exposes older rocks in its core, and is cut by more intrusions. Even though the two districts are separated by a gap of 250 miles, in which our knowledge is relatively slight, it is tentatively concluded that they are parts of the same geological province.

Age of the Cariboo Group

The age assigned to the Cariboo group depends on fossil collections from a limestone which is exposed from Bowron Lake to Kimball Creek and has been traced into the Cunningham limestone of the Roundtop Mountain area. Fossil collections were made by the writer near Bowron Lake, on Iltzul Ridge, Turks Nose Mountain, and Kimball Creek, and by Lang at Kimball Creek. No fossils have been found in the Cariboo group in the Antler Creek area or the Yanks Peak-Roundtop Mountain areas.

Lang's collection at Kimball Creek is more extensive and varied than the writer's, but there is no record of the distribution of the fossils at the various localities. Lang's collection was examined by C. E. Resser, and his identification is stated by Lang (1947, pp. 31–32) as follows:—

Pædeumias sp.
Kootenia sp.
Salterella sp.
Bonnia sp.
New genus related to *Kootenia.*
New genus of Olenellid trilobite.

Dr. Resser reported that all the above were Lower Cambrian, with the possible exception of the genus related to *Kootenia*, which could be Lower or Middle Cambrian. He also stated that the same unnamed genus of Olenellid trilobite, and possibly the same species, occurs in the Eager formation near Cranbrook, B.C.

The writer spent much time searching the localities marked by Lang (Map 561A) but was unsuccessful except at the northwestern locality, where a meagre collection of deformed trilobites was taken in black slate interbedded with the Cunningham limestone. The stratigraphic position of the locality is not certain but appears to be in the upper part of the formation. Professor V. J. Okulitch, of the University of British Columbia, identified the writer's collections. From this locality were identified:—

Bonnia sp.
Trilobite not identifiable.

At Turks Nose Mountain, collections were made at 500, 700, and 1,400 feet above the base of the limestone. At 500 feet rare archæocyathids were found which were identified as:—

Coscinocyathus sp.
Pycnoidocyathus sp.

At 700 to 750 feet above the base and for several miles along the face of the mountain a zone is exposed that is composed of 50 to 60 per cent of ellipsoidal algal remains which were identified as:—

Girvanella.

At 1,400 feet above the base, in 20 feet of interbedded fawn-coloured slate, fragments and rare whole trilobites were collected which were identified as:—

Wanneria sp.
Olenellus cf. gilberti.

On Iltzul Ridge one indistinct archæocyathid was found, identified as possibly:—

Protopharetra.

On a hill between Bowron Lake and Indian Point Lake abundant archæocyathids were found which were identified as:—

Ajacicyathus sp.
Coscinocyathus sp.
Pycnoidocyathus sp.

Rare trilobites and fragments found in 12 feet of fawn-coloured slate interbedded with the archæocyathid-bearing limestone were identified as:—

Olenellid trilobite possibly *Callavia.*
Genial spine of Olenellus(?).
Olenellus cf. thompsoni.

The combined archæocyathid and trilobite zone is at least 200 feet thick and is at least 500 feet above the base of the formation, which is covered.

Professor Okulitch concluded:—

The fauna clearly indicates the upper Lower Cambrian. The trilobites are similar to the Eager fauna from near Cranbrook; and the Archæocyatha resemble the ones from the Donald formation.

Early Cambrian fossils have thus been collected from 500 to 1,400 feet above the base of the Cunningham limestone, which is about 2,000 feet thick; only on Turks Nose Mountain are the stratigraphic positions of collections known precisely. It can be concluded that much of the Cunningham limestone is Lower Cambrian, and that the remainder of the Cariboo group is most likely Middle Cambrian and later.

The Base of the Cambrian System

Many authors recognize as the base of the Cambrian system either the first major unconformity or the first major change in lithology below the Olenellus Zone (King, 1949; Kay, 1951, p. 7). By the first definition as much as 10,000 to 15,000 feet of unfossiliferous strata may lie within the Cambrian in some localities in the world, and by the second, 3,000 to 4,000 feet. Wheeler (1947) has stated cogent reasons why the base should be defined as the first appearance of fossils characteristic of the Olenellus Zone, but this definition is not practical in regions of reconnaissance mapping or in rocks that have been regionally metamorphosed and deformed. In such rocks a few fossils may be found, but commonly most signs of life have been destroyed, and hence in much of the Canadian Cordillera a less precise but more practical definition is needed. King (1949, pp. 636–638) concluded that in the southern Appalachians the most practical stratigraphic procedure was to take as the base of the system the first major change of lithology of regional extent below the Olenellus Zone. This is the only solution applicable in the Cariboo District, where preservation of fossils can be regarded as accidental. Therefore, the base of the Cunningham limestone is taken as the base of the Cambrian system, 500 feet below beds in which fossils of the Olenellus Zone have definitely been found. The base of the Cunningham is readily recognizable and appears to be regionally extensive, hence it usefully marks the base of the Cambrian system.

Correlation

Lower Cambrian rocks form a considerable portion of the rocks, not only of the Rocky Mountains, but also of the Columbia and Cassiar-Omineca Mountains. West of the Rocky Mountain trench, regions formerly thought to be underlain almost exclusively by Precambrian rocks have been shown by work in the last decade to include widespread and abundant Lower Cambrian rocks. The following is a partial list of formations in British Columbia that are entirely or in part correlative with the Cunningham formation, listed from north to south. A recently prepared correlation chart shows the relations of units in the Rocky and Purcell Mountains (North and Henderson, 1954).

(1) Atan group, McDame area, Cassiar Mountains (Gabrielse, 1954).
(2) Ingenika group, Aiken Lake area, Omineca Mountains (Roots, 1954).
(3) Mural formation, Mount Robson, Rocky Mountains (Burling, 1923).
(4) Donald and St. Piran formations, Dogtooth Mountains, Columbia Mountains (Evans, 1933).
(5) St. Piran (Peyto) formation, Mount Stephen, Rocky Mountains (Rasetti, 1951).
(6) Eager formation, Cranbrook area, Columbia Mountains (Rice, 1937).
(7) Laib group, Salmo area, Columbia Mountains (Little, 1950, pp. 15–18).

In unmapped areas, archæocyathids have been collected from the Misinchinka schists on the Hart Highway (Holland, personal communication), and archæocyathids and olenellid trilobites (Lay, 1941, p. 21) from near Sinclair Mills on the great bend of the Fraser River. At the latter locality the collections are from a thick limestone and interbedded slate that the writer believes from examination to be a northern extension of the Cunningham formation. Thus Lower Cambrian rocks are extensively represented along the west as well as the east side of the Rocky Mountain trench throughout its length in British Columbia.

The Cunningham limestone includes fossils of latest Early Cambrian age, and so the remainder of the Cariboo group may be Middle Cambrian or later. Middle Cambrian rocks are less well known in the Columbia or Cassiar-Omineca Mountains than are those of the Lower Cambrian. The only Middle Cambrian formations so far described are the Nelway formation of the Salmo area (Little, 1950, pp. 18–21), Eager (in part), Burton (in part), and Canyon Creek formations, Purcell Mountains (*see* North and Henderson, 1954), and Atan group (in part), McDame area, Cassiar Mountains (Gabrielse, 1954).

The Kaza group is equivalent in stratigraphic position to the Horsethief Creek formation of the Purcell and Western Ranges of the Rocky Mountains, and the Hector and Miette formations of the Main Ranges of the Rocky Mountains near Banff and Jasper respectively. The Kaza group resembles in some degree the lithology of all these formations. All are latest Precambrian.

Age and Correlation of the Slide Mountain Group

The palæontological evidence is inconclusive, but it indicates that the age of the Slide Mountain group is Carboniferous, and possibly Mississippian (*see* p. 36). However, the Slide Mountain group is believed to be the equivalent of the Cache Creek group, and hence may be Pennsylvanian or even Permian in age. The sections described in Appendix B match very closely sections on the west side of Beaver Creek valley, 45 miles southwest of Slide Mountain. These latter sections have not been described in detail but have been examined by the writer. They are part of the main belt of Cache Creek rocks that extends between the type locality near Ashcroft and Stuart Lake (Armstrong, 1949, p. 50).

Ages of Deformations

The ages of deformations are not known with any precision. Local evidence indicates that the first major folding took place after the Early Cambrian and before the Carboniferous, and the second after the Carboniferous and before the Tertiary. Other areas in the northern Cordillera were deformed in the Palæozoic to an extent and with an intensity only now becoming apparent. Rice and Jones (1948, p. 4) have shown in the Salmon Arm area that Cache Creek rocks rest unconformably on granite and serpentinized peridotite. M. Y. Williams (1944, p. 15) has shown Proterozoic and (or) Cambrian rocks of the northern Rocky Mountains to have been sharply folded prior to the Middle Silurian. Buddington and Chapin (1929, pp. 281–289) in southeastern Alaska found repeated angular unconformities in Palæozoic sections extending from early Ordovician to Permian, and stated that a disturbance of considerable intensity may have occurred during the Silurian. Roots (1954, pp. 193–194) found evidence in the Omineca Mountains of a post-Cambrian pre-Carboniferous deformation. Gabrielse (1954) described a marked structural discordance between rocks of Middle and Late Ordovician age in the Cassiar Mountains. Thus, at widely separated localities in the northern Cordillera, there is evidence of strong orogeny in the early Palæozoic. If a single orogeny is represented, its most probable age would seem to be late Ordovician to early Silurian.

The Slide Mountain group may have been folded at the same time as the Quesnel River group (Jurassic and Lower Cretaceous) because the degree of deformation in the two groups is comparable, or before the Quesnel River group because the absence of rocks of Early or Middle Triassic age in British Columbia indicates this was a time of uplift and possibly compression. The deformation was completed prior to the peneplanation, which is thought to be of Early Tertiary age.

Contrasts between Cariboo and Slide Mountain Groups

The Slide Mountain group presents certain comparisons and contrasts with the Cariboo group, in rock suites, deformation, and source direction. Rock suites give evidence of the type of environment in which they accumulated. In the Cariboo group there is an upward progression from sediments typical of a stable environment toward those typical of an unstable one. The rock typical of the upper part of the group, subgreywacke (*micaceous quartzite*), is a mature rock composed dominantly of quartz and mica. There is little indication of volcanism in the Cariboo group. These characteristics indicate the Cariboo group is of miogeosynclinal origin. In contrast to the Cariboo group, the Slide Mountain group is composed of immature greywackes, chert, and argillite intercalated with large amounts of spilitic pillow lavas and sills. Hence the Slide Mountain group is typical of a eugeosyncline and in fact represents the eastern limit of the Cordilleran eugeosyncline in British Columbia (or Fraser Belt, *see* Kay, 1951, p. 35). The evidence in the Cariboo District leads to the conclusion that either the Cordilleran eugeosyncline came into being only after the Cambrian or its eastern boundary moved eastward before the late Palæozoic.

An inverse relationship exists between the degree of crustal instability indicated by the sediments and the degree of deformation to which they have been subjected. The Cariboo group formed under stable to mildly unstable conditions but has been severely deformed, whereas the Slide Mountain group formed under conditions of severe crustal instability, but has been only moderately deformed. As already shown, the deformation of the Cariboo group seems to have preceded, by a considerable period, the deposition of the Slide Mountain group. Thus the fate that commonly overtakes eugeosynclinal deposits did not overtake the Slide Mountain group and, conversely, the Cariboo group, which is not eugeosynclinal, has been subjected to most severe deformation.

Source of Sediments

The source of sediments in both groups appears to have been in the west. In the Cariboo group the Midas and Snowshoe formations coarsen toward the west and the percentage of calcareous rocks in them decreases. The source would appear to be a border land composed of igneous or metamorphic rocks.

In the Slide Mountain group the following evidence indicates a source southwest of the present outcrop belt: the rock types present in Guyet conglomerate could only have come from the west, and slump structures in the banded rocks of the Antler formation indicate an initial dip toward the northeast. Finally, at Beaver Creek, 45 miles southwest of Slide Mountain, the section of Cache Creek rocks is similar to that at Slide Mountain and dips at similar angles but toward the southwest. It would seem possible that these two similar sections were built by deposits shed from a central arch of Cariboo group rock exposed as a tectonic island or peninsula southwest of the Antler Creek area.

CHAPTER VI.—ECONOMIC GEOLOGY

INTRODUCTION

The Antler Creek area is an important source of lode and placer gold. The Cariboo Gold Quartz and Island Mountain mines at Wells have produced more than 32 million dollars in bullion from 1932 to the end of 1954. Placer-mining has probably produced an equivalent amount, although only 15 million dollars is officially recorded because accurate statistics were not kept until thirteen years after the original gold-rush of 1861. Current yearly lode-gold production (1954) has a value greater than 1½ million dollars, whereas current placer-gold production ranges between one-tenth and one-fiftieth of this figure.

This report is limited to lode. Placer was not studied because Bowman's maps of the placer creeks (1895) and Johnston and Uglow's report are accurate and thorough, and little could be added to them. This chapter contains much information drawn from earlier reports on lode properties and obtained from the staffs of the operating mines.

HISTORY OF LODE-MINING

The history of lode-mining in the Cariboo District is one of repeated unsuccessful ventures from the early 1870's until 1933, and since then of pulses of intense activity followed by periods of quiescence. In the years following the peak placer production of 1863, interest became directed for the first time to the many quartz veins in the area. Many of the large veins were examined and tested in the 1870's. These were chiefly veins striking parallel to the foliation of the surrounding rocks (the A veins of Johnston and Uglow). In 1877–78 much prospecting was done, principally on the following veins: *Bonanza, Steadman, Pinkerton* (*see* Cariboo Gold Quartz, p. 74), Black Jack (*see* Westport, p. 91), Proserpine, Island Mountain, and the Perkins, and others on Mount Burns adjacent to the present map-area. The weathered and enriched upper parts of some of these veins yielded encouraging assays, but work at depth did not. Below the zone of surface weathering the gold was largely contained in pyrite, and was not recoverable by the milling practice of the time. Not until the development of modern milling methods were any of the veins, large or small, in reality ore.

Little work was done from 1878 until 1886, when a period of activity started that lasted until 1891, partly as a result of the building of a custom mill at Barkerville by the Provincial Government and partly stemming from Bowman's geological survey. Bowman made the first systematic geological study of the area and examined and sampled most of the known veins. He delimited the area of gold-bearing placers and veins and pointed out the spatial relation between them. The veins already mentioned were the chief ones tested in this period, the most successful exploration being at the Black Jack.

From 1891 until 1922 almost the only work was the systematic testing of most of the veins in the district by C. J. S. Baker and A. J. R. Atkin, starting in 1902, and by E. E. Armstrong in 1916.

In 1922 Uglow examined the veins of the district, and his report (Johnston and Uglow, 1926, p. 187) did a service to the miners of the area by recognizing two types of veins and drawing attention to the difference in value between these types. He called A veins those with a strike essentially parallel to the foliation of the enclosing rocks, and B veins those cutting the foliation at from 45 to 90 degrees. The A veins are the larger and more conspicuous, but commonly contain relatively small amounts of sulphide minerals and gold; the smaller B veins may be well mineralized.

A small number of prospectors, including E. E. Armstrong, C. J. S. Baker, T. Blair, J. J. Butts, A. W. Sanders, F. J. Tregillus, and Fred M. Wells, prospected from Island Mountain to Mount Proserpine with an intensity increased by the knowledge gained from Uglow's work. In 1927 The Cariboo Gold Quartz Mining Company Limited was formed to develop veins on Cow Mountain, first by adits from Lowhee Creek and in later years by a long adit from Jack of Clubs Lake. A favourable exchange rate and a revaluation of gold in 1932 spurred general activity in the Cariboo District, and the Cariboo Gold Quartz mine was brought into production in January, 1933. The Aurum group, which had been held for a long time by C. J. S. Baker and had been optioned by several companies, was finally purchased by Newmont Mining Corporation, which formed Island Mountain Mines Company Limited in 1933. Development work revealed a new type of ore—gold-bearing pyrite replacement of limestone. A mill was built, and production started on November 1st, 1934. In 1933–34 Hanson mapped the "Barkerville Gold Belt" in detail and studied the mineral deposits. Numerous underground workings had been opened since Uglow's mapping, and with this advantage Hanson was able to classify the quartz veins more accurately. He divided the veins into four groups—(1) transverse veins, (2) diagonal veins, (3) strike fault veins, (4) bed veins; (1) and (2) were together equivalent to Uglow's B veins, and (3) and (4) to the A veins (Hanson, 1935, p. 13; *see also* p. 66). Hanson's work was of great assistance to mine operators and prospectors, and if his recommendations had been fully carried out (1935, p. 18), significant replacement ore might have been found at the Cariboo Gold Quartz mine earlier than it was.

In the years prior to 1942 the two mines increased production and, along with other companies, continued developing the prospects in the area. In 1940–41 the Cariboo Gold Quartz Mining Company drove the main haulage level to the B.C. vein and sank the old B.C. shaft to meet it; Island Mountain purchased the Myrtle and Shamrock groups and extended the old Shamrock adit; and Privateer Mine Limited did much stripping on the Proserpine Gold Mines property and extended the Warspite adit. By 1942 the full effect of the war began to be felt; production fell and prospecting virtually stopped.

A new round of development and prospecting started in 1945, when Barkerville Mining Company did detailed geological mapping and intensive prospecting on its extensive holdings on Proserpine Mountain, and Canusa Cariboo Gold Mines, Ltd. started to sink a shaft. In 1946 Canyon Cariboo Gold Mines Limited and Williams Creek Gold Quartz Mining Company Limited started the examination of their properties. During these two years extensive development work was done at the Cariboo Gold Quartz and Island Mountain mines. The Cariboo Gold Quartz main shaft was sunk to 550 feet below the main haulage level, and at the Island Mountain mine the lower levels were developed from the shaft that had been deepened to 1,450 feet below the main haulage level in 1942. By 1948, however, this burst of activity was over; the camp was quiet and the mines sustained financial losses because of the steady increase in costs. In 1952 Island Mountain suspended all active exploration and development, and in 1954 the mine was sold to the Cariboo Gold Quartz Mining Company.

It is hoped that the consolidation of Island Mountain mine and the Cariboo Gold Quartz mine may return prosperity to the camp. The new arrangement increases efficiency by milling all ore at the Cariboo Gold Quartz mill and provides deep access to both the Cariboo Gold Quartz mine and its Mosquito Creek property. The search for new replacement ore is being carried on vigorously.

CHARACTERISTICS OF LODE DEPOSITS

The lode deposits of the Antler Creek area are gold-bearing pyritic quartz veins and bedded replacements. These two types of orebodies are related in origin, but they will be treated separately because of their different form. Lodes have been found only within the Cariboo group.

Quartz Veins

Quartz veins are common and are widely distributed in the Cariboo group. Although some veins are very large, most are small and in some places are closely spaced. In general the sulphide content is low, but in certain areas they contain a fairly consistent quantity of pyrite with attendant gold.

A pattern of occurrence of quartz veins has long been recognized. Bowman, Uglow, and Hanson all noted this pattern. Hanson (1935, p. 12) named four types of veins:—

Type	Strike Relative to Foliation	Dip
Transverse	Transverse	Steeply southeastward.
Diagonal	Diagonal (i.e., easterly)	Steeply southeastward.
Strike fault	Subparallel	Steep.
Bed	Parallel	Parallel to bedding.

Hanson's general classification of veins is substantially correct in the mine area, but the writer eliminates " bed " veins because they are insignificant and includes them with the strike veins. Veins of an additional type are recognized—the northerly veins. These veins were deposited in the northerly striking faults and were brecciated by subsequent movement. They are not drag ore as is commonly supposed. The writer therefore proposes the following classification:—

Type	Strike	Dip
Transverse veins	North 30°–55° east	70° southeast to 70° northwest.
Diagonal veins	North 70°–90° east	Steeply southeast.
Northerly veins	North-north 20° east	45° to 80° east.
Strike veins	North 40°–60° west	Steeply southwest to 60° northeast.

The first three types of veins are related to the pattern of faults and joints described on pages 53 to 55 and shown on Figure 13. Ideally, transverse veins fill the AC joints (extension joints), diagonal veins fill the minor easterly striking faults, and northerly veins occur in the northerly striking faults. The vein pattern and vein characteristics indicate the filling of a conjugate fracture pattern. The strike veins are not related to this pattern, and contrast with the other types of veins in a number of respects. The strike veins are essentially parallel to the regional foliation.

Veins commonly occur in clusters that branch and ramify from one orientation to another both along strike and down dip. This is especially characteristic of diagonal and transverse veins (*see* Fig. 19).

In the Wells mining camp two controls in the distribution of veins are particularly clear—a relation to northerly faults and to lithology. The northerly faults antedate vein formation but have been subject to post-vein movement. These conclusions are drawn from the following facts: The veins are clustered about the northerly faults but those in one wall do not match those of the other, the density of veins decreases sharply a few hundred feet from the faults, and veins occur in the fault planes but are brecciated. The vein clusters are normally restricted to one rock type, which most commonly is Snowshoe micaceous quartzite, and rake down dip within these strata.

Transverse veins strike north 30 to 55 degrees east and most commonly dip 70 to 90 degrees southeast. In the Cariboo Gold Quartz mine they are vertical or dip steeply northwest. They are the smallest veins and are by far the most numerous. There are countless fractures, thousands of veinlets, and hundreds of known veins with the transverse attitude. Mineable veins are commonly less than 100 feet long and 1 foot wide and are mineable only because they occur in clusters. The veins cut sharply across the country rocks, and although they may be shattered they are not crushed or folded. They fill tensional openings that are ideally AC joints and are most numerous adjacent to northerly faults. Some of the larger veins may be formed along several closely aligned fractures; these fractures may have been slightly *en echelon* on dip, and the vein group as a whole normally has a steeper dip than the individual fractures. Diagonal veins commonly fray out into a group of transverse veinlets both along strike and down dip.

At the Island Mountain mine the transverse veins are normally too small to mine except in positions adjacent to diagonal veins or east of the Jack of Clubs fault. At the

Cariboo Gold Quartz mine they are somewhat larger and are more closely spaced; they provide 60 to 75 per cent of the quartz ore. In both mines they are generally the highest-grade veins. Normally an entire vein is considered as one oreshoot and usually is mined as one of a group by selective cut and fill methods.

Diagonal veins strike north 70 to 90 degrees east and dip steeply southward. Diagonal veins are fewer, more widely separated, and larger than transverse veins. Some known diagonal veins are about 5 feet wide and extend 250 feet horizontally and vertically, although the average vein is probably less than 150 feet long. Not uncommonly the diagonal veins occupy fractures that are minor faults with small left-hand displacement. The diagonal fractures and veins occur predominantly adjacent to major northerly striking faults. Commonly the diagonal veins have a great number of tributary transverse veins. Not rarely where a transverse vein joins a diagonal a streak of pyrite in the centre of the transverse vein will continue into the diagonal vein, probably indicating that the sulphide mineralization is younger than the quartz mineralization of the diagonal veins.

The diagonal veins are about a fifth as numerous as transverse veins at the Cariboo Gold Quartz mine. At Island Mountain mine only the diagonal veins normally are mineable. In general the diagonal veins are lower in grade than the transverse, and there is a suggestion that the grade of a diagonal vein is related to the number of tributary transverse veinlets. Commonly not all of a diagonal vein is of mineable grade.

Northerly veins commonly strike between north and north 20 degrees east and dip 50 to 70 degrees eastward. They occur within the northerly striking faults and commonly are completely crushed by subsequent movement. They are not well known because they are relatively rare and difficult to explore. In the Wells camp they invariably occur in ground that is nearly impossible to mine because of dilution and difficulty of support, but a few have been mined nevertheless. In the Yanks Peak-Roundtop Mountain area, the largest veins are of this type (Holland, 1954, p. 40).

Strike veins are subparallel in strike to the regional foliation, namely, north 40 to 60 degrees west. Most veins dip more steeply northeastward than the foliation, and some dip steeply southwestward. It is not clear whether the veins fill a group of minor fractures or faults, but in some instances there has been some minor post-vein faulting parallel to the walls. Wisps and inclusions of country rock and irregular bulges in the veins probably indicate that replacement was important in their formation. They are cut by northerly and easterly striking faults (*see* Fig. 17).

Strike veins are the largest in the area but are relatively few in number. They are prominent features and were the first veins to be investigated. The B.C. vein is the largest known; it is 2,400 feet long, as much as 42 feet wide, and has been developed to a depth of more than 900 feet. The Canusa vein is longer than 500 feet and is 9 to 11 feet wide.

Strike veins are normally sparsely mineralized or barren of sulphide minerals but may contain large isolated masses of pyrite. These masses carry little gold. Uglow stated that oreshoots were likely only at junctions with transverse veins, and Holland (*Minister of Mines B.C.*, Ann. Rept., 1948, p. 90) indicated that the higher gold values in the Canusa vein occurred near minor crosscutting faults. The only strike vein to have been mined is the B.C. vein, from which three oreshoots containing visible gold have been mined.

Replacement Deposits

Replacement deposits have been found to date only in the Wells camp, and there only at limited horizons and localities. Most deposits are in the Baker limestone beds of the Snowshoe formation, between the Rainbow fault and the northwest boundary of the Island Mountain property. Other thin limestone members intercalated in the Snowshoe formation are common, but have not yet been very productive. Some rare bedded orebodies replace argillaceous rocks.

The replacement deposits consist of massive fine-grained pyrite which has entirely or selectively replaced the rock. Coarse grey ankerite commonly forms an envelope surrounding a deposit and may occur as streaks within it. Siliceous replacements and other sulphide minerals are rare.

Replacement orebodies may be pencil-shaped or tabular, the form depending chiefly on the fold structures of the host rock.

Pencil-shaped orebodies lie along the crests of folds and plunge with them at 20 degrees toward north 55 degrees west. The cross-section of an orebody may be of the order of a hundred square feet, but the length may be over a thousand feet (*see* Fig. 22). Pencil-shaped orebodies are localized in the crests of anticlinal folds and less commonly in synclines. The largest and most continuous body occurs in the crest of the major dragfold in Island Mountain mine. Pencil-shaped orebodies have been found only in this mine.

Tabular orebodies normally have a dip length slightly greater than strike length, the maximum dimension being of the order of 150 feet. The bodies occur on planar limbs of folds. Tabular bodies are characteristic of the Cariboo Gold Quartz mine but also occur at Island Mountain mine. At the former mine it has been found that commonly several orebodies are stacked in a group at slightly different horizons, with only minor overlapping in vertical projection (*see* Fig. 20). In such cases the limestone is particularly thick (as great as 100 feet) and may be isoclinally folded, although no folds can be seen and there is no evidence that ore may be localized on fold crests.

It would seem from the distribution of the different shaped orebodies in different settings that the folds have controlled the migration of ore-forming fluids. These fluids appear to have migrated chiefly up plunge where constrained to do so by impervious phyllite hoods and up dip where not constrained.

A relation exists between faults, veins, and replacement deposits. The relation to faults is not too well defined, but so far all bodies are within " ore making range " of major northerly faults. The relation to veins is more obvious; transverse veins appear to be the feeders from which the mineralizing fluids spread. Benedict (1945, p. 768) states that in Island Mountain mine:—

> No diagonal vein has been found extending into the limestone replacement horizon, but a fair proportion of the stronger transverse veins do so. Specific examples of massive sulphide replacement in the limestone at the intersection with such (transverse) veins have been noted. . . . It seems clear that at least some proportion of the solutions forming the replacement orebodies entered the limestone via the (traverse) veins.

At the Cariboo Gold Quartz mine transverse veins commonly extend to the base of a replacement body and may continue through it with replacement ore extending outward like wings. Such bodies are locally called replacement flippers. On the fringes of some orebodies minor transverse veinlets are common, from which thin pyritic streaks extend in a Christmas-tree pattern into selective laminæ of the limestone.

In both Cariboo Gold Quartz and Island Mountain mines the gold content per ton of replacement ore is commonly more than double that of quartz veins, chiefly because of the greater concentration of pyrite in the replacement ore rather than a higher value of the pyrite. Benedict (1945, p. 755) states that at Island Mountain mine to the end of 1944 replacement ore averaged 0.83 ounce per ton, compared to 0.34 for quartz ore. At Island Mountain approximately 25 per cent of the ore milled has been replacement ore. The corresponding figure for the total production of the Cariboo Gold Quartz mine is near 4 per cent, but replacement ore is currently contributing a percentage considerably greater than that.

Mineralogy

The mineralogy of the quartz veins and replacement bodies is similar. Gold is the mineral of value. Silver is relatively unimportant because the ratio by weight of gold to silver in both types of ore is approximately 10 to 1. The precious metals are chiefly contained in pyrite, the dominant and commonly the sole sulphide mineral. A number of other minerals occur in minor amounts, including galena, sphalerite, cosalite, bismuthinite, scheelite, pyrrhotite, arsenopyrite, and chalcopyrite.

Pyrite is sparsely distributed throughout most veins but also occurs concentrated in streaks along the walls, in the centres of veins, or as irregular masses. Streaks of pyrite not uncommonly are associated with transverse veins, and at vein intersections the pyrite streaks may continue from the transverse into diagonal or strike veins. Commercial veins normally contain 15 to 25 per cent of pyrite which assays 1 to 2 ounces per ton or better. In general, fine-grained pyrite has a higher assay than coarse. The gold is contained chiefly in small fractures in the pyrite. Visible gold occurs erratically, normally in fine particles. Together with cosalite and bismuthinite it is commonly associated with those parts of veins which have vugs containing well-terminated quartz crystals. Needles of cosalite and blebs of bismuthinite both commonly contain very finely divided interstitial gold. High-grade ore may be intensely mineralized with pyrite, or be less pyritic and contain cosalite, bismuthinite, free gold, and vuggy quartz.

Minor minerals in veins include galena, sphalerite, and scheelite, which occur erratically in moderately large blobs; arsenopyrite, pyrrhotite, and chalcopyrite, which are rare; and ankerite and muscovite, which, in addition to quartz, are the common gangue minerals.

Replacement ore normally consists of massive fine-grained pyrite with but few other minerals, except near the margins of orebodies. Commonly the finest-grained pyrite is the most auriferous and may assay as much as 5 ounces per ton. Even after dilution a replacement stope commonly averages better than 0.8 ounce per ton. The ore may be massive, but commonly contains bands of ore separated by bands of grey ankerite or, more rarely, phyllite. Toward the fringes of the orebodies, ankerite becomes dominant and pyrite becomes more sporadic and coarser grained. There may be some silicification near the fringes and also minor amounts of galena, sphalerite, arsenopyrite, and scheelite.

AGE OF MINERALIZATION

Johnston and Uglow (1926, pp. 20, 38–39) believed the gold mineralization was earlier than the deposition of the Slide Mountain group because a specimen of Guyet conglomerate was thought to contain placer gold, some quartz veinlets in Proserpine intrusives contained traces of gold, and no gold-bearing veins had been found in the Slide Mountain group. Some years later a prospector (J. Doody) took forty bulk samples of Guyet conglomerate and only three assayed as much as a trace in gold. The gold in these, as in Johnston and Uglow's samples, may possibly have resulted from inadvertent "salting" from surficial deposits. The gold-bearing veinlets in the Proserpine sill could be of any age later than the sill and not necessarily related to it. The third reason lacks conviction when it is considered that vein and placer gold is extremely rare in the Cariboo group adjacent to the Slide Mountain group.

The gold mineralization is believed by the writer to be later than the formation of quartz veins. The veins are later than most of the northerly fault movement because they are concentrated beside the northerly faults, they occur in a conjugate set of fractures related to the faults, and they actually occur within the faults themselves. The major faulting and the vein formation took place later than the major folding of the Cariboo group and after the deposition of the Slide Mountain group. The mineralization is older than the gold-bearing Tertiary gravels. Therefore, on the evidence in the map-area the gold mineralization may have occurred between the Carboniferous and Early Tertiary. Outside the map-area auriferous quartz veins occur in the Quesnel River group (Late Triassic to possibly Early Cretaceous). It is not unlikely that those of the map-area are of Mesozoic age.

DISTRIBUTION AND GENESIS OF VEINS

Quartz veins are found in the Cariboo group throughout the district, but there are several places where they are especially abundant. Not all are gold-bearing, but where veins are abundant they normally are gold-bearing. Veins are predominantly small, and in general it is only where they are abundant and closely spaced that they can be mined.

It was pointed out by Bowman (1889, pp. 29–30c) that there is a restricted area in which placer gold is found, and that although quartz veins occur throughout the district, they are most numerous in this restricted area. Bowman's general ideas are probably more nearly correct than Hanson's specific concept of a Barkerville Gold Belt. This concept was of one particularly favourable stratigraphic horizon, the "Rainbow member," which dipped and faced northeastward and was not known to be repeated by folding. Much energy was expended in prospecting this "horizon" and looking for its extensions beyond Island Mountain and Grouse Creek. Hanson's idea was valuable inasmuch as it concentrated attention on a particularly rich area, but its too rigid application led to the belief that prospecting beyond the "Rainbow member" was useless. It is now known that the "Rainbow member"—i.e., the lower part of the Snowshoe formation—is repeated by folding in many places although not with the same wealth of veins. The existence of favourable strata is not sufficient reason for the occurrence of mineable veins.

A possibility exists that the quartz veins may be of more than one origin and that the gold-pyrite mineralization may not be directly related to the formation of the veins. The evidence is suggestive rather than conclusive, but it can be stated strongly that not all quartz veins in the area are of hydrothermal origin.

Many quartz veins, widely distributed throughout the area, have the characteristics of locally derived secretions. Typically, these veins occur in quartzites or micaceous quartzites. They are barren veins almost devoid of minerals other than quartz. Some have irregular form, but most are regular and fit the fracture pattern. Many of the veins that appear secretional are strike veins, but not all strike veins are demonstrably of this type; alternatively, some are mineralized and others occur in schistose argillaceous rocks. However, the mineralization in strike veins is definitely closely related to transverse fractures or veins, and many of the veins in argillaceous rocks may be extensions of veins occurring in and derived from quartzose rocks. Veins of secretional type are abundant at Mount Burdett, Roundtop, Antler, and Bald Mountains, where they are found in all the classified orientations but dominantly the strike direction.

Most other quartz veins have some characteristics similar to those of secretional veins and some features that are significantly different. They also are largely restricted to the quartzites and micaceous quartzites. They may be barren of hydrothermal minerals in some places but not in others. The greater frangibility of the quartzites has been invoked to explain the localization of these veins in quartzites, but many of the micaceous quartzites are very fissile and no stronger than the phyllites. Also it is strange that if these veins were deposited from hydrothermal solutions, the adjacent limestones were not silicified. In contrast to the secretional type of vein, the close spatial relation of the other veins to northerly faults and related fracture patterns would seem to indicate such veins were more likely of hydrothermal origin.

The gold-pyrite mineralization may be younger than and only indirectly related to the main mass of veins, whatever their origin. Many veins are barren, except adjacent to transverse fractures or veins. In transverse veins the pyrite commonly occurs in streaks that suggest the filling of reopenings, and where such veins meet diagonal or strike veins the streak of pyrite will commonly continue in the same orientation through the other vein. Transverse veins are also judged to be feeders of the replacement deposits, which have essentially no siliceous envelopes such as should be present if the deposition of quartz were synchronous with the gold-pyrite mineralization. It appears that the mineralization is younger than the quartz veins and has largely followed the same conduit system and been distributed chiefly via the transverse fractures.

The principal features which may be used as guides in the search for ore deposits are the northerly striking faults and the presence of readily fractured rocks. The northerly striking faults occur throughout the area, and, although they appear to be particularly numerous in the vicinity of the mines, that may be because work has been concentrated there. Careful search may turn up many more faults elsewhere. Quartzites and siltstones which may be readily fractured are common throughout the area and commonly contain quartz veins. Many of the veins are barren, and it is obvious that still other factors have been vital in creating or controlling orebodies. Very commonly mineralized veins are associated with a relatively steep plunge of folds. The significance of the steep plunges may simply be that intense faulting has occurred, for the plunge is compensated by faults (*see* p. 55), and it is the faulting that is important. Rock alteration by bleaching or, less commonly, silicification occurs in the same general locality as veins, but is related to the northerly faults rather than to the mineral deposits and thus forms only a general target for exploration. Ankeritization is also common near veins, but is so regionally distributed and so intense near some dykes that it is of little use as a guide to mineralization. Probably the most important general guide is the spatial relation between placer and lode distribution. However, it must be remembered that the placer concentration is the result of erosion of veins and not an indicator of veins that have not been exposed. Veins are found more readily than replacement deposits, and search for the latter orebodies should be pressed in areas of numerous mineralized veins.

The relation between gold-bearing lode deposits, numerous veins, and rich placer deposits is best illustrated in the area between Island and Proserpine Mountains. Creeks draining this area include many of the most productive in placer gold in the Cariboo District, e.g., Williams, Lowhee, and Mosquito Creeks, and Stouts and Conklin Gulches. Part of this area has altered rocks and steep plunges which, though not directly related to the veins, are related to the vital northerly faults. Other localities in which placer deposits, numerous veins, large plunges, and alteration are all present include Antler and Nugget Mountains in the vicinity of the Antler fault, and upper Cunningham Creek and Peter Gulch in the Antler and the Yanks Peak-Roundtop map-areas.

CHAPTER VII.—DESCRIPTIONS OF PROPERTIES

The mining properties of the Antler Creek area are described in alphabetical order, using the name most firmly established for a property rather than a company name. In some instances, consolidations of well-known properties or groups have resulted in the use of more than one name for a property.

Figure 15 shows surveyed claims in the northern part of the area, grouped according to ownership. It includes all Crown-granted and most recorded claims held in the map-area in January, 1955. Important underground workings are shown and are numbered in sequence from northwest to southeast. These numbers also appear on the geological map (*see* Fig. 2) and in square brackets under the heading of the property description.

A check-list of names and lot numbers of mineral claims shown on Figure 15 forms Appendix C.

Aurum.—*See* Island Mountain [1].

Canusa [5]

Canusa Mines Ltd. (name changed from Canusa Cariboo Gold Mines Ltd. in August, 1956) holds two Crown-granted claims and twenty-four recorded claims and fractions stretching up Cow Mountain from Lowhee Creek and Stouts Gulch. The property is adjacent to the southern end of the Cariboo Gold Quartz property. The mine buildings and shaft are at the head of Stouts Gulch and about 2,000 feet south of the B.C. shaft of the Cariboo Gold Quartz mine. The underground workings consist of a 300-foot two-compartment vertical shaft, from which extend a 350-foot crosscut and 600 feet of drift.

The Canusa vein is not naturally exposed at surface, and most of the smaller veins were deeply covered by overburden until hydraulic mining exposed them in the 1930's. The ground was located as the Blue Jay group in the 1930's and a moderate amount of prospecting done, including the driving of a short adit by Cariboo Central Gold Mines Ltd. south of the Black Bull vein, but no extensive work was done until the present company was formed. In 1946 the shaft was sunk; the Canusa vein was discovered in 1947 and explored the following year. The mine was shut down and allowed to flood at the end of August, 1948.

Bedrock is generally mantled by drift in the vicinity of the mine, except in the hydraulic pits on Lowhee Creek and Stouts Gulch. The rocks exposed in these are dominantly brown-weathering grey micaceous quartzite, commonly with dark or opalescent quartz grains. The average grain size ranges from that of granule to silt. The mine dump is composed of similar rocks which are not yet weathered brown. Lesser amounts of grey to brown phyllite, a few small limestone beds, and one schistose greenstone dyke occur. All rocks are typical of the lower part of the Snowshoe formation. Black argillite of the Midas formation flanks the outcrop belt of the Snowshoe formation on both sides of the valley, along the Lowhee ditch on the southwest, and adjacent to the B.C. vein on the northeast. Outcrops are too few to show the precise contacts.

The general structure is a tight syncline of Snowshoe rocks flanked by anticlines of Midas rocks, the lesser one being that on the northeast (*see* Fig. 17). The structural interpretation is based primarily on stratigraphy, but confirmation can be obtained on lower Stouts Gulch from cleavage-bedding relations and small dragfolds. Evidence of the anticlinal nature of the area of Midas formation in which the B.C. vein occurs is found on the 1500 level of the Cariboo Gold Quartz mine. Bedding and cleavage strike between north 40 to 60 degrees west and dip between 35 and 70 degrees to the northeast. Northwest of the shaft the folds plunge to the northwest at 10 to 15 degrees, but southeast of the shaft the folds plunge as much as 15 degrees to the southeast. This is one of the few major reversals in plunge in the map-area.

There are no major faults, but two northerly striking faults of moderate displacement are adjacent to the mine. The Waoming fault, with a horizontal separation of possibly a few hundred feet, is about 700 feet east of the end of the east drift. The B.C. fault, with a horizontal separation of just over 100 feet, cuts the northeast end of the B.C.

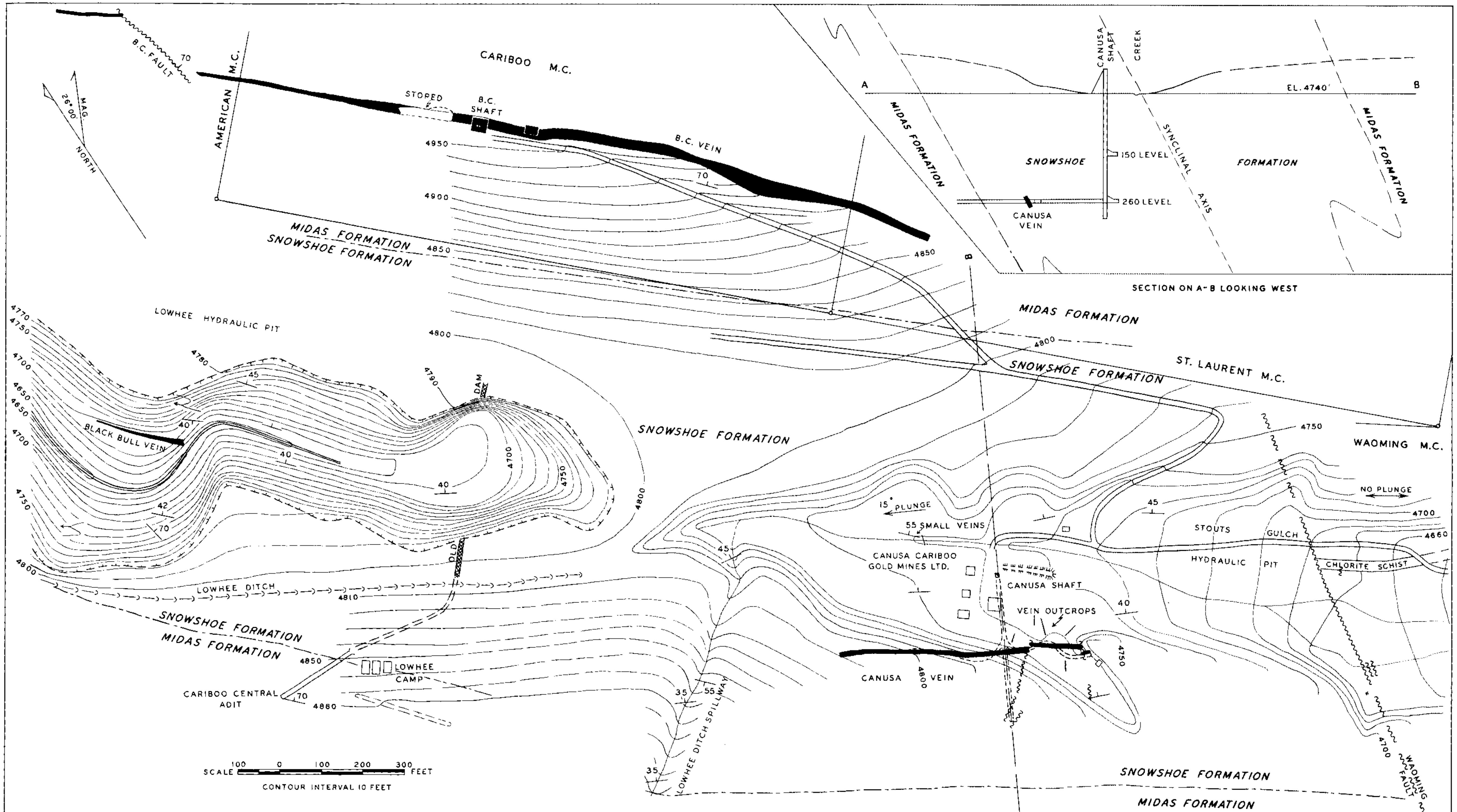


Figure 17

Geology in vicinity of Canusa and B.C. veins in upper Stouts Gulch and Lowhee Creek (after Holland 1948) vein, and its projection would pass within 700 feet of the northwest drift. Small faults that cut the Canusa vein all displace the vein less than 16 feet.

The main surface showings consist of two groups of veins, small transverse quartz veins mostly south of the shaft, and strike veins in the upper end of the Lowhee pit. All the small veins near the shaft strike approximately north 20 degrees east and dip steeply west, except one which strikes in the diagonal direction, approximately north 70 degrees east. The veins are all narrower than 18 inches, and the longest is about 75 feet long. These veins are vertically above the main Canusa vein and their relation to it is unknown. The Minister of Mines Annual Report for 1945 (p. 81) quotes assays of pyritic concentrations in these veins that yielded as much as 0.14 ounce of gold per ton, and of thin replacements adjacent to the veins with as much as 0.70 ounce of gold per ton.

The main vein in the upper part of the Lowhee pit, called the Black Bull vein, is about 900 feet southwest of the B.C. vein and about 2,000 feet northwest of the Canusa shaft. The Black Bull vein, like the B.C. and Canusa, is a strike vein. The main part of it is 210 feet long, but vein matter extends discontinuously for another 600 feet to the northwest from the main part. It is 12 feet wide at the widest part at the southeast end, where it terminates abruptly without faulting. The vein appears barren because much of the pyrite is leached, but pyrite concentrations have yielded assays of 0.14 and 0.32 ounce of gold per ton. Similar but smaller subparallel veins occur near the northwestern extension of the vein. Gold is reported to have been panned from the quartz of these veins, but there is no assurance that it was not placer gold.

The mine workings are now flooded but have been examined by Holland (*Minister of Mines, B.C.*, Ann. Rept., 1948, pp. 87–90). The following is quoted with minor revisions from his report:—

> The underground workings on the 260-foot level from the shaft comprise some 950 feet of crosscutting and drifting. The crosscut is driven south 27 degrees west for 350 feet. For 150 feet the crosscut intersects medium- and dark-grey (phyllite and micaceous quartzite). The next 145 feet consists of light-grey to white quartzite with thin argillaceous layers, grey ankeritic carbonate layers, and thin beds of rice-grained quartzite. For the last 55 feet to the face the rocks are grey argillaceous schist and dark-grey and black slate, with the black slate at the face. They are considered to belong to the (Midas formation). The rocks strike north 85 degrees east to north 75 degrees west and dip 35 to 60 degrees northward.
>
> At 175 feet south of the shaft the crosscut intersects the Canusa vein, which ranges from about 9½ to 11 feet wide, dips northward at about 65 degrees, and strikes about north 60 degrees west. The vein is drifted for 200 feet south-east of the crosscut and for 390 feet north-west.
>
> The vein is cut by ten faults having lateral displacements of from 1 to 3 feet and by two with displacements of 12 and 16 feet. Their direction of movement is not constant, nor do they fall into a definite pattern. They strike north-east or north-west and have variable dips.
>
> The quartz in some places is fractured at right angles to the strike of the vein and in others is crossed by a network of younger quartz-filled fractures. It is mineralized rather sparingly with pyrite and contains galena, some sphalerite, cosalite, and occasionally some visible gold. The vein was systematically sampled at 10-foot intervals by the company in July, 1948. The samples were taken across the quartz exposed in the drift, but do not represent the full width of the vein. The numerical average of forty-nine samples is 0.17 oz. gold per ton, thirty samples assayed less than 0.11 oz. per ton, nine lay between 0.11 and 0.2 oz. per ton, two lay between 0.2 and 0.3 oz. per ton, four between 0.31 and 0.4 oz. per ton, and four assayed more than 0.5 oz. per ton. There is an indication that the better than average assays usually come from sections where the vein is shattered near a crosscutting fault. However, the best assays were from samples containing cosalite taken 50 feet from the nearest fault.
>
> One selected sample, well mineralized with pyrite, taken by the writer near the fault 25 feet south-east of the crosscut, assayed 0.18 oz. of gold per ton. Another selected sample well mineralized with pyrite and cosalite from the stringer on the east wall of the crosscut 70 feet south of the Canusa vein also assayed 0.18 oz. of gold per ton.
>
> The last work on the Canusa vein was the continued driving of the north-westerly drift toward the southward projection of the B.C. fault. The fault was expected to be 100 to 300 feet north-west of the crosscut, but at 390 feet still had not been encountered. The B.C. fault is of interest because of the hypothesis that better values might be expected in the Canusa vein in the shattered zone on either side of the fault in a similar situation to that at the surface on the Cariboo Gold Quartz Mining Company's ground where the B.C. vein contains a 75-foot ore-

shoot on each side of the B.C. fault, and on 1500 level where the B.C. vein had an ore-shoot (now stoped) on the south-east side of the B.C. fault. Consequently there is good reason to expect that the Canusa vein, because of its size and because it contains appreciable though submarginal gold values, will contain ore-shoots under similar favourable structural circumstances.

[References: *Minister of Mines, B.C.*, Ann. Rept., 1945, pp. 80–81; 1946, pp. 90–91; 1947, pp. 112–113; 1948, pp. 87–90.]

Cariboo Coronada [2]

The Cariboo Coronada property consisted of a group of recorded claims on the south side of Mount Cornish and was developed by two adits in 1933–34, but the claims have since lapsed and the company, Cariboo Coronada Gold Mines Limited, is without equity. The main adit is one-half mile north of Wells at the base of Mount Cornish. It is now caved at the portal. The adit is reported to have been driven north 13 degrees west for more than 1,300 feet but did not reach its objective, which was the downward projection of a group of veins on Mount Cornish 700 feet in elevation above the portal. The veins on the surface are northerly to transverse in strike, and one is reported to be 8 feet wide.

The rocks on the property are very poorly exposed phyllite, metasiltstone, limestone, and some quartzite of the Snowshoe formation. The adit is near the axis of the Snowshoe synclinorium.

[References: Hanson, 1935, p. 36; *Minister of Mines, B.C.*, Ann. Rept., 1934, p. C 25.]

Cariboo Gold Quartz [3] [4]

The Cariboo Gold Quartz Mining Company Limited owns 102 Crown-granted claims and fractions in an unbroken block 2 miles wide and 4 miles long extending from Mosquito Creek to Stouts Gulch. The property includes the Island Mountain mine, which was purchased in 1954 and is treated separately in this chapter. The following description deals only with the holdings owned prior to 1954 and does not include the Westport group of a subsidiary company, Williams Creek Gold Quartz Mining Co. Limited. The property, thus restricted, surrounds the Island Mountain mine on three sides and includes the townsite of Wells. The Cariboo Gold Quartz mine workings extend southeasterly from Jack of Clubs Lake through Cow Mountain to the B.C. vein at the head of Lowhee Creek, a distance of 2 miles.

Gold-bearing quartz veins on what is now Cariboo Gold Quartz property have been examined repeatedly since the 1870's. Most of the early work was done on the B.C. (Bonanza) vein, but some was done on the Pinkerton and Enterprise veins (both on the Pinkerton claim, Lot 356). B.C. Mining and Milling Company brought a 20-stamp mill to the B.C. vein in 1878 but did not erect it. In the next ten years this company sank an inclined shaft in the vein approximately 150 feet, drove a few hundred feet of drift, and did some drilling but mined little ore. During the same period the Victoria Company did some underground exploration on the Pinkerton and Enterprise veins, sinking a 150-foot shaft on the former. From the 1880's little was done until the early 1920's, when A. W. Sanders located the Rainbow group. He did much surface work and mined the weathered, enriched surficial part of several veins.

The Cariboo Gold Quartz Mining Company Limited was formed in 1927 by Fred M. Wells and acquired the Pinkerton claim and the Rainbow group. Thereafter, other claims were located or purchased, so that by 1932 the company held most of its present property except the Island Mountain (Aurum).

In 1927 an adit was driven at 4,375 feet elevation toward the downward projection of showings on the Rainbow claim at approximately 4,800 feet (now the Sanders zone of the mine). Several veins were encountered, but the adit was abandoned in 1930 before the main objective was reached. In 1931 an adit (the 1500 level) was driven at approximately 4,000 feet elevation from a portal about 100 feet above Jack of Clubs Lake. The hope that mineable veins would be encountered *en route* to the same objective was fulfilled, and a mill was brought into production in January, 1933. The initial capacity of

50 tons per day was increased in several stages to 350 tons per day by 1940. Mine development proceeded rapidly in this period, mainly from the 1500 level. By 1942 four shafts had been sunk and the 1500 level extended over 2 miles to meet the B.C. shaft. Total production of the mine to the end of 1953 has been 1,407,354 tons of ore, from which 520,235 ounces of gold and 45,046 ounces of silver have been recovered. To January 31, 1954, the mine has produced $19,123,980, of which $1,679,976 has been returned as dividends. Production in 1953 totalled 65,214 tons, from which 26,140 ounces of gold and 2,331 ounces of silver were recovered.

The mine workings are extensive, totalling more than 25 miles. The portal of the 1500 level [3] is situated on the Telluride (Lot 7798) at the northeast end of Jack of Clubs Lake directly opposite the Island Mountain 4000 level portal. The 1500 level extends southeastward for over 2 miles to the inclined shaft on the B.C. vein [4]. There are two higher adit levels on Cow Mountain, the 1200 and 1000 levels. Veins are concentrated in the Snowshoe micaceous quartzite (Rainbow member) close to northerly striking faults which are spaced at approximately 1,000-foot intervals. The ore zones are thus isolated from one another, and each has been developed above and below the 1500 level with relatively few interconnecting levels. The level interval is 110 feet. The ore zones are named from northwest to southeast: Tailings (below Jack of Clubs Lake), No. 1 (at the 1500 level portal), Rainbow, Sanders, Pinkerton, Butts, Goldfinch, and B.C. Vertical shafts extend downward from the 1500 level in the No. 1 zone (to the 2000 level), Rainbow, and Sanders zones (both to the 1900 level); an inclined shaft extends in the B.C. zone from surface to the 1500 level; and raises extend upward from the 1500 level to higher adit and internal levels in the Rainbow, Sanders, Pinkerton, and Butts zones. The shaft in the Sanders zone is no longer used, and servicing is chiefly carried out by the three-compartment shaft in the No. 1 zone. Ore from the Island Mountain mine is hoisted at that mine and trucked to the Cariboo Gold Quartz mill.

The structure and stratigraphy at the Cariboo Gold Quartz mine cannot be discussed without reference to the description of Island Mountain mine (pp. 82–85) or to the outline of the fold structures of the Wells camp (p. 53). The workings of the two mines, Figure 16, are almost directly in line along strike, and information gathered from one mine complements that from the other.

The following description of the stratigraphy and structure must unfortunately be complicated by reference to earlier work. In the mine, Hanson (1935, pp. 22–23) mapped four subdivisions of the Rainbow member that in his text were named divisions 2a, 2, 3, and 4 from southwest to northeast; all dipped at 45 degrees to the northeast and faced in the same direction. The approximate equivalence of these divisions to the sections described by the writer is shown in the tables on page 76.

Subsequent writers (Richards, 1948, p. 163; Skerl, 1948b, pp. 574–578) have used Hanson's subdivisions but have revised the order of numbering: Hanson's uppermost unit, No. 4 division, now being called No. 1 band; his No. 3 division now being called No. 2 band, etc. Following Benedict's demonstration of a large overturned dragfold at Island Mountain mine, geologists concerned with the problem considered Hanson's section "upside down." Thus Skerl (1948b, p. 576) lists as oldest to youngest the Baker, Rainbow, Lowhee, and B.C. members. Skerl mentions Hanson's divisions but lists them in reverse order without comment. He states (p. 576) that Nos. 1 and 3 bands (Nos. 4 and 2 divisions of Hanson) are alike, that Nos. 2 and 4 bands are light coloured, and arbitrarily that No. 4 band is Lowhee member. No. 2 band, he believes, results from infolds of two different members. He states:—

> The so-called No. 2 band appears to be in part a large elongated infold of the Baker horizon in No. 3 zone (Sanders ore zone) and in part a similar fold of the Lowhee horizon in No. 1 and No. 2 (Rainbow) zones.

Hanson apparently used colour as one of the bases of his subdivisions but did not say so. Skerl recognized that some rocks were bleached (p. 576), but he also used colour as a guide in mapping. The writer has found colour an unreliable guide in the vicinity of Wells, where bleaching is pronounced and widespread.

The Cariboo Gold Quartz mine workings are in the Snowshoe and Midas formations. Foliation strikes northwestward and dips about 45 degrees northeastward; bedding is not normally distinguishable. The following tables present in simplified form the sections exposed in two continuous crosscuts on the 1500 level; the first extends along the 201 crosscut, from the portal, and the second along the 241 North and South crosscuts, 2,400 feet southeast of the portal (*see* Fig. 16). Thicknesses are measured normal to the foliation (without regard to possible duplication by folding). Between the Midas formation and the Baker limestone beds six members are recognized, and are lettered a to f. The sequence has only local significance because the units are duplicated by the Sanders isoclinal syncline. The position of the axial plane cannot be determined and the syncline cannot be seen directly (*see* p. 53).

201 CROSSCUT

Regional Units	Subdivision	Thickness in Feet	Lithology	Hanson's Units	Mine Units
Snowshoe formation.	Baker limestone beds.	28	Light-coloured phyllite.	Baker member.	Baker member.
		7	White limestone.		
		28	Light-coloured limy phyllite.		
	f	57	Grey micaceous quartzite.	No. 4 division.	No. 1 band.
		42	Grey phyllite, minor quartzite.		
	e	122	Grey phyllite with quartzite lenticles.		
	d	78	Bleached phyllite, minor quartzite.	No. 3 division.	No. 2 band.
	c	110	Grey micaceous quartzite.	No. 2 division.	No. 3 band.
	b	26	Grey phyllite with quartzite lenticles.		
	a	50	*Grey phyllite and quartzite.*		
Midas formation.		200	Black argillite and phyllite, some bleached.	B.C. member.	No. 4 band (Lowhee) and B.C. member.

241 NORTH AND SOUTH CROSSCUTS

Regional Units	Subdivision	Thickness in Feet	Lithology	Hanson's Units	Mine Units
Snowshoe formation.	Baker limestone beds.	35	Green limy phyllite.	Baker member.	Baker member.
		35	Black limestone and phyllite.		
		56	Grey and bleached phyllite, minor quartzite.		
	f	56	Grey quartzite and phyllite, some bleached.	No. 4 division.	No. 1 band.
		100	Grey micaceous quartzite and phyllite.		
	e	78	Grey phyllite with quartzite lenticles.		
	d	44	Grey quartzite, some bleached.	No. 3 division.	No. 2 band.
		55	Bleached phyllite and quartzite.		
	c	57	Grey micaceous quartzite.	No. 2 division.	No. 3 band.
	b	15	Grey phyllite with quartzite lenticles.		
	a	55	Grey phyllite and quartzite.		
Midas formation.		42	Bleached fawn-coloured phyllite.	No. 2a division.	No. 4 band or Lowhee.
		63	Bleached greenish phyllite.		
		210	Black argillite, some bleached.	B.C. member.	B.C. member.

Comparison of the 201 and 241 sections shows general similarity but some differences in thickness and lithology. The thickness of the units varies between sections, partly because of small-scale duplication by folding and partly because of attenuation. The lithology varies because of lenticularity of units and because of bleaching.

The phyllite with quartzite lenticles forming units b and e requires special mention. This rock may contain varied proportions of quartzite lenticles, which may be of varied sizes up to 5 feet long (*see* Fig. 18). The streamlined shape and arrangement of the lenticles preclude a sedimentary origin. The rock has obviously been intensely deformed, and the writer agrees with Skerl (1948b, p. 576) that this rock is the result of great attenuation. Figure 18 illustrates a small-scale occurrence of this rock on one limb of a torn syncline.

Bleaching of Snowshoe and Midas rocks is important. However, the proof of bleaching is not obvious except on the fringes of bleached areas. In fringe areas, bleaching is proved by patchy distribution, particularly along the line of plunge, kernels of unbleached rocks within bleached rocks, and penetration of bleaching along cleavage and AC joints into unbleached rocks. Bleaching is most intense near large northerly faults and extends from them along the regional foliation in the form of serated wedges.

Bleached rocks range in colour from fawn to silver to light green, depending on small differences in the relative abundance of muscovite, chlorite, and ankerite. Bleached rocks commonly contain veinlets of red-weathering, clear cherty quartz that are parallel to the foliation or the AC joints. It is not clear whether this quartz was introduced into or derived from the bleached rocks.

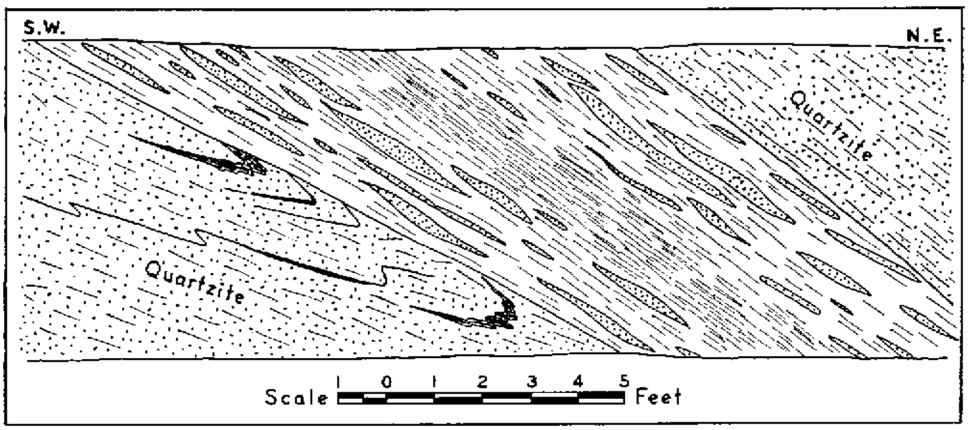


Figure 18. Sketch of torn syncline, Snowshoe formation, Cariboo Gold Quartz mine, 241S crosscut.

Some vague forms in the fringe areas of mixed bleached and unbleached rocks may sometimes be taken for dragfolds. Most of them have no continuity along plunge and are undeterminable; some possibly are relics of folding, much modified by bleaching. Skerl (1948b, p. 597) illustrates a section of drill core and of a crosscut wall showing jagged interpenetration of dark and light argillite which he calls dragfolding. The writer would interpret such a feature as penetration of bleaching into dark argillite.

The main fold structure of the Wells mining camp is the Sanders attenuated isoclinal syncline, which is one of a series of folds lying between the Island Mountain anticlinorium to the southwest and the Snowshoe synclinorium to the northeast. The syncline trends northwestward through the centre of the mine and, in common with all in the area, is overturned to the southwest. Evidence of the existence of the syncline can be found, but the fold itself has not been recognized. Discussion of the Sanders syncline is found on page 53.

In the mine small dragfolds in the Midas formation (*see* Fig. 16) all indicate a syncline to the northeast. In the Baker limestone beds small dragfolds mostly indicate a syncline toward the southwest. The dragfolds in the Midas formation are not as tight as those in the Snowshoe, but in the vicinity of the mine the Midas formation is homogeneous and has acted as a massive structural unit so that dragging has not been extreme. The Sanders syncline must lie between the Midas formation and Baker limestone beds. The axial plane probably lies within unit d or e, but, because the actual fold cannot be detected, its exact position is not known and the extent of duplication of and the precise relations between units a to f are not known. Because of original lenticularity and subsequent attenuation, the two limbs would not be expected to be lithologically identical.

The minor folds within the mine plunge northwestward at 15 to 25 degrees, except in the vicinity of large northerly faults, where they are dragged so that the plunge is reduced, eliminated, or reversed. The net effect is to reduce the over-all plunge.

Faults in the mine are numerous. The most important are the northerly striking, easterly dipping faults, which are spaced roughly 1,000 feet apart. These are named, from northwest to southeast, Tailings, No. 1, Rainbow, Sanders, Lowhee, Goldfinch, and B.C. The Lowhee and Rainbow and possibly the Goldfinch are considerably larger than the other faults. The Lowhee fault dips 70 degrees east and has a right-hand horizontal separation of about 1,400 feet. It is essentially a normal fault, as is shown by considerable dragging of the plunge; its vertical component is unknown but is certainly large. In the vicinity of the mine workings the Lowhee fault has one important fault splaying from it, the Lowhee split, which branches from the main fault about 500 feet south of the main haulageway. The Rainbow fault dips 50 to 60 degrees to the east, and has a right-hand horizontal separation of 300 to 400 feet. It is also essentially a normal fault with a vertical component at least as great as the horizontal. The other faults are smaller and have the following horizontal separations: 100 feet on the No. 1, 20 feet on the Sanders, and 150 feet on the B.C. In general the smaller faults have flatter dips than the Lowhee and Rainbow faults.

The foliation is deflected and the plunge flattened within 200 feet of the Lowhee and 100 feet of the Rainbow fault. The foliation is deflected from north 75 degrees west to north 45 degrees west, and the plunge from an average of 22 degrees northwestward to horizontal.

Minor faults in the mine include easterly striking faults and " bedded " faults. The easterly faults are related to the northerly faults, against which they abut. They dip steeply southward and have very small left-hand horizontal separations. They are commonly filled with diagonal veins. The bedded faults strike northwestward and dip subparallel to the foliation. They commonly follow phyllitic beds, and some are marked by a foot of contorted and crushed phyllite. The faults have a moderate left-hand separation caused by the upper plate moving down plunge. Such faults appear to be most numerous where the plunge of folds is high. Figure 19 shows a bedded fault and its relation to the Rainbow fault.

The relation of veins to faults in the Cariboo Gold Quartz mine is most marked. The known veins are concentrated within 250 feet horizontally of the northerly striking faults. Diagonal veins are most numerous adjacent to the larger faults. Skerl (1948b, p. 585) states that veins are commonly wider and richer adjacent to the bedded faults. Vein matter has been deposited in the northerly faults and crushed by later movement. Veins on opposite walls of faults cannot be matched, proving that the faults existed prior to mineralization but were subject to later movement. So close a spatial relationship leads to the idea that the faults have served as conduits for the mineralization.

Veins of all types occur within the Cariboo Gold Quartz mine. Transverse veins are by far the most abundant and supply 60 to 75 per cent of the quartz ore. Diagonal veins are the next most abundant and supply most of the remaining quartz ore. The other types of veins are comparatively rare, but have been mined. The principal strike vein is the B.C. vein.

Transverse and diagonal veins commonly form a matted cluster. Figure 19 shows two typical vein combinations: one in which transverse veins splay from a dominantly diagonal vein, and one in which there is a complex interweaving between transverse and diagonal directions. These relations occur on dip as well as strike.

The veins normally occur in one type of rock and diminish at its boundaries. Thus the vein clusters rake northeastward with the dip of the enclosing strata. The commonest host rock is the micaceous quartzite of the lower Snowshoe formation, but veins may occur in Snowshoe phyllite or Midas argillite.

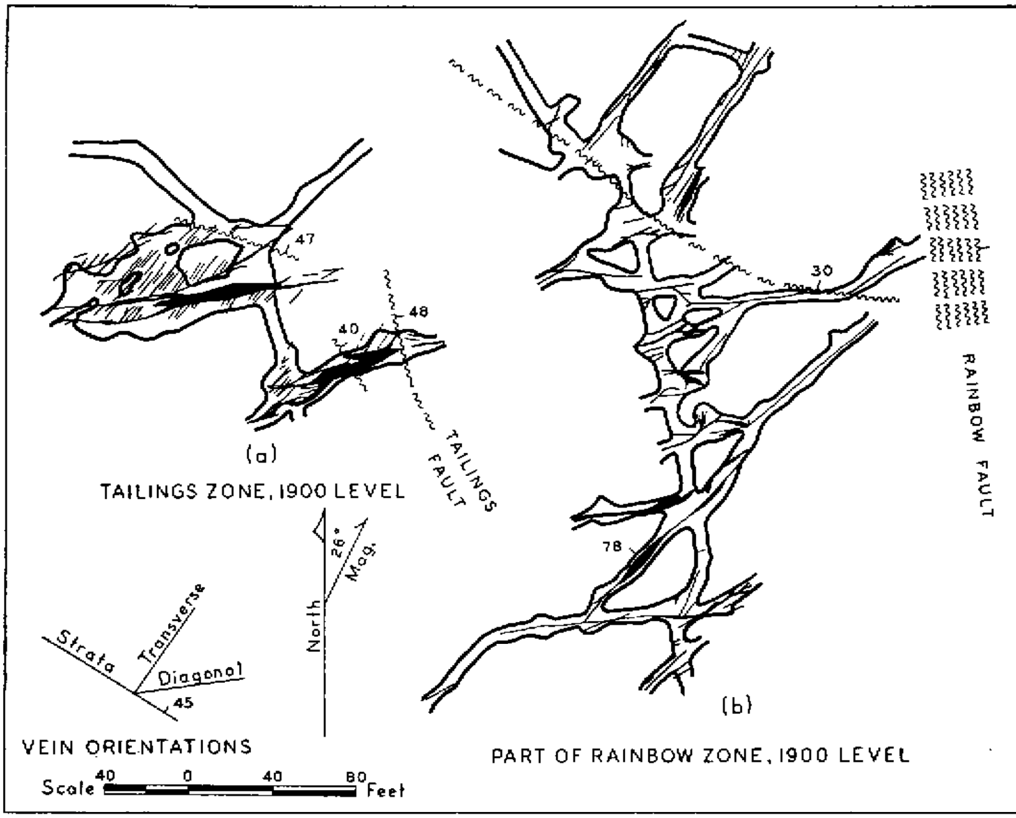


Figure 19. Typical vein patterns, Cariboo Gold Quartz mine (after company plans).

The largest known strike vein in the map-area is the B.C. vein [4]. This vein is 2,400 feet long, as great as 42 feet wide, and has been developed over 900 feet vertically. It strikes north 45 degrees west and dips about 70 degrees northeastward. The vein cuts the schistosity of the Midas formation at a small angle. Some of the adjacent rocks are bleached in a patchy manner, especially in the hangingwall. Figure 17 shows the surface trace and its relation to the Canusa vein. At the 1500 level, 900 feet below the surface, the vein is thin and discontinuous. Three oreshoots have been mined, but the ore is reported to present problems in milling.

Replacement deposits were not found until 1944. Up to August, 1953, 42,176 tons, with an average grade of 0.548 ounce per ton of gold, had been mined, mostly since 1948. So far all important replacement orebodies have been found in the Baker limestone beds between the Sanders fault and Island Mountain mine. No extensive limestone equivalent to the 309 limestone beds of Island Mountain is known, but almost certainly there is an equivalent to the Johns limestone that remains unexplored.

The replacement orebodies are tabular, with greater continuity along the dip of strata than along the plunge of folds. They have been found to occur in groups at slightly different horizons with only minor overlap in plan. Figure 20 shows two stopes of such a group. Skerl (1948b, p. 589) suggested that these orebodies occur at compressed overturned dragfolds. This is a possibility, but the writer saw no confirmatory evidence.

[References: Johnston and Uglow, 1926, pp. 208–209; Hanson, 1935, pp. 22–26; Richards, 1948, pp. 162–168; Skerl, 1948b, pp. 571–597; *Minister of Mines, B.C.*, Ann. Rept., 1927, pp. 169–171; 1933, pp. 120–123; 1934, pp. C 20–21; 1945, pp. 73–79; *B.C. Dept. of Mines*, Bull. 1, 1932, pp. 59–61; Bull. 3, 1932, pp. 10–13.]

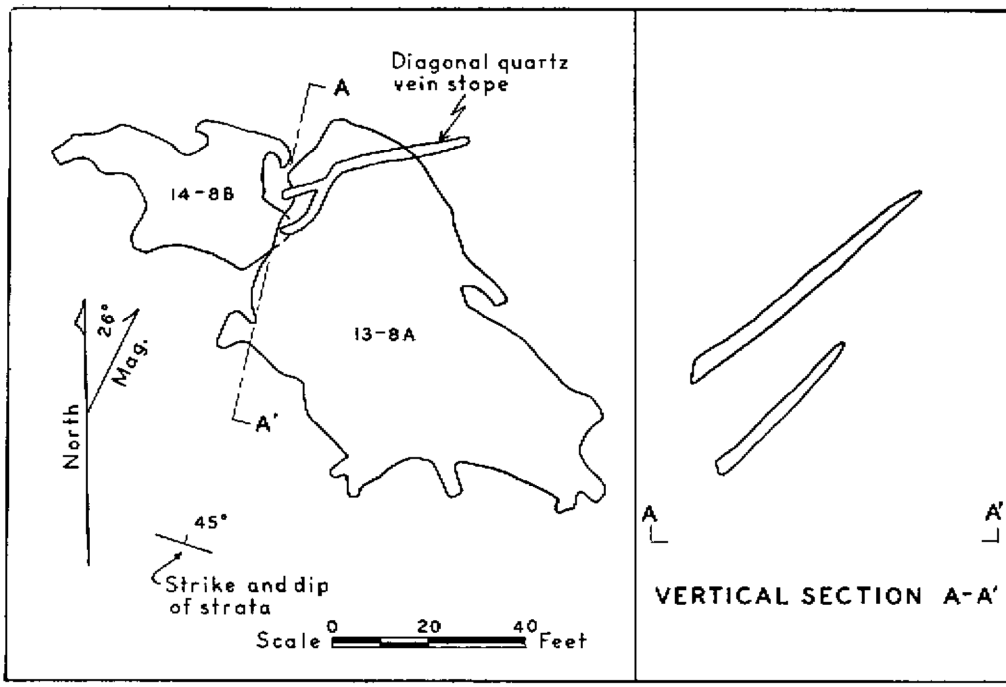


Figure 20. Diagrammatic plan and section of replacement stopes (after company plans).

Gisco, Spitfire, etc. (Canyon Cariboo Gold Mines Limited) [15]

The Gisco and Spitfire are two of a large group of recorded claims that once blanketed southern Antler Mountain and northwestern Nugget Mountain from Sawflat Creek to Wolf Creek. The claims were held by Canyon Cariboo Gold Mines Limited and included the Noranda, Zone, Lode, Pittman, and Norex groups in addition to the Gisco and Spitfire. All except some of the Noranda and Lode groups had lapsed or been transferred by January, 1955, when only nine claims were in good standing.

Antler Creek was one of the richest placer-gold creeks. A few large veins on Antler Creek were examined in the 1860's and 1870's but were almost barren of gold. Sporadic prospecting was done during the 1930's, but exploration was not extensive until the present company started work in 1946–47.

Rock exposure is good, along Antler Creek and parts of Wolf Creek and China Pass, but elsewhere bedrock is deeply mantled by drift. The area of the original large group of claims is underlain mostly by Snowshoe formation and in the northern part by black phyllites and argillites of the Midas formation. All the rock types of the Snowshoe formation are present—micaceous quartzite and siltstone, phyllite, and small limestone lenses. The major structure is the Snowshoe synclinorium, the axis of which crosses Antler Creek in the vicinity of Victorian Creek and is offset 2 miles northward by the Antler fault. Numerous minor folds and small dragfolds can be identified, but the complexity is such that the folds within the Snowshoe formation cannot be described in detail. Isoclinal folding is characteristic of the area, and numerous examples of isoclinal dragfolds can be seen. Within the Midas formation the crest of an anticline occurs near the confluence of Pittman Creek with Antler Creek. This is one of a series of folds rising on the southwest limb of the Cunningham anticlinorium. The major fault in the vicinity and the largest in the area, the Antler fault, passes through the claims with a northerly strike. The main fault is exposed by placer workings at the head of the China Pass pit. The trace of the main fault leaves Antler Creek at California Gulch and continues along China Pass and the valley of Sawflat Creek and Swift River. The fault has a right-hand horizontal separation of approximately 2 miles. A number of lesser faults splay from the Antler fault in the vicinity of Pittman Creek. There are at least three subparallel minor faults and one moderate-sized fault.

The exploration work by the company was described by Holland (*Minister of Mines, B.C.*, Ann. Repts. 1946, p. 94; 1947, pp. 114–115) and is quoted below.

> The Gisco group consists of ten claims staked along the west side of Antler Creek and extending northward from Sawmill Flat. The main showing on the group, the Gisco vein, is about 50 feet above creek-level, on the west side of Antler Creek opposite the mouth of Victoria Creek. About 1,200 lineal feet of bulldozer stripping was done parallel to Antler Creek, to the north and south of the Gisco vein. The Gisco vein lies in grey flaggy quartzite that strikes north 45 degrees west and dips 75 degrees north-east. The vein-fracture strikes north 80 degrees east and dips 70 degrees north. The vein has a maximum exposed width of 12 inches and a length of about 40 feet before it pinches where the fracture crosses soft argillaceous rocks. The vein-quartz is mineralized with pyrite, galena, and rare specks of visible gold. The highest assay of a sample taken by the owners is reported to be 0.32 oz. gold per ton. A sample of picked pieces containing 15 per cent pyrite and about 5 per cent galena assayed: Gold, 0.01 oz., and silver, 1.8 oz. per ton. Several 1- to 2-inch quartz stringers lie on the foot-wall side of the vein. Ten feet on the hanging-wall side a 1- to 2-inch stringer is exposed, from which samples containing visible gold have been obtained and from whose outcrop fine flour gold may be panned.
>
> To the north of the Gisco vein is a 25-foot limestone-bed. In it is a vein well mineralized with chalcopyrite. A selected sample of chalcopyrite assayed: Gold, 0.01 oz. per ton; silver, 10.5 oz. per ton; and copper, 26.9 per cent. No other veins were exposed.
>
> The Spitfire group of nine located claims is on the west side of Antler Creek between Wolfe Creek and the head of California Gulch. During the summer E. S. Dowsett was engaged in prospecting these claims. He discovered a vein-zone having a known length of about 500 feet and a width of about 350 feet lying 700 to 900 feet in elevation above the China Creek cabin and on the north side of Wolfe Creek. The quartz veins occur in groups of individual veins 2 to 3 feet apart. The veins are stripped for lengths of about 20 feet; the greatest exposed width of any vein is 6 inches. The veins strike north 50 degrees east, stand vertically, and cut grey flaggy quartzite striking north 45 degrees west and dipping 65 degrees north-east. The quartz is mineralized with pyrite, most of which has been leached from the outcrops. Of the numerous veins found and partly stripped, possibly one-half contain fine flour gold that may be panned from the weathered exposures.
>
> On the Zone group, about 500 feet south-east of the Antler Creek bridge, a group of five sub-parallel veins was found on the south side of a low ridge. The veins, which strike north 25 degrees east and which cut vertically through grey thinly fissile ankeritic schist, are from 2 to 16 inches wide, and were stripped for short distances. They are very sparsely mineralized with pyrite and some arsenopyrite, and small amounts of fine gold may be panned from certain of the oxidized outcrops.
>
> Four flat drill-holes, totalling about 400 feet, were drilled at an elevation of about 50 feet below the outcrop. These crossed narrow widths of sparsely pyritized quartz, from which the highest assay was 0.06 oz. gold per ton.
>
> Two narrow parallel quartz veins were found on the east side of Antler Creek, 150 feet down-stream from the Gisco vein, which occurs opposite Nugget Gulch. Fine visible gold could be seen in the quartz-outcrops, from which most of the pyrite mineralization had been leached. One flat drill-hole, 25 feet below the outcrop, intersected several 4- to 10-inch quartz veins, one of which, at a distance of 83 feet from the collar of the hole, assayed 0.81 oz. gold per ton.
>
> Five holes, totalling about 200 feet, were drilled to test the downward extension of the Gisco vein. Vein quartz was intersected in two of the holes, but no core was recovered from the others.
>
> Toward the close of the 1947 season a discovery of replacement mineralization was made on the Pittman group, near the mouth of Victoria Creek. Although some of the rock was well mineralized with galena and sphalerite, as well as pyrite, the gold and silver content is low. A picked piece containing galena, and sphalerite in abundance, assayed: Gold, trace; silver, 1.1 oz. per ton; lead, 4.9 per cent.; and zinc, 34.9 per cent.
>
> Up to the present time all veins found on the Spitfire, Gisco, Zone, and Pittman groups have been short, narrow, and sparsely mineralized, even though gold may be panned from the oxidized vein material or fine visible gold may be seen in their oxidized outcrops. There is a considerable number of these veins clustered on both sides of a zone of limestone-beds that crosses Antler Creek just down-stream from the Gisco vein. Under favourable conditions this limestone-zone might form a locus for replacement mineralization, which, if it were gold-bearing, could be of considerable interest and economic importance. For this reason it should be worth considering as a zone for intensive prospecting.

For several years following 1947 the company employed E. S. Dowsett to continue prospecting the holdings. He panned scheelite from the overburden on many of the Zone and Spitfire claims and found some small scheelite replacements of limestone. In 1952 some bulldozer stripping was attempted on claims of the Zone group, but in general the overburden was too deep.

[References: *Minister of Mines, B.C.*, Ann. Rept., 1946, p. 94; 1947, pp. 114–115.]

Island Mountain (Aurum) [1]

This property consists of thirty-two Crown-granted claims and fractions extending up the southeastern slopes of Island Mountain from the shore of Jack of Clubs Lake. The mine workings are mainly on the Aurum (Lot 10517) and Aurum West (Lot 11066) in the northeastern part of the group. The property was owned by Island Mountain Mines Company Limited, a subsidiary of Newmont Mining Corporation of New York, and was bought in August, 1954, by The Cariboo Gold Quartz Mining Company Limited. The mine has been renamed the Aurum, but the name Island Mountain is retained in this bulletin.

The history of the property is given in summary by Holland (*Minister of Mines, B.C.*, Ann. Rept., 1950, pp. 102–103) and is quoted as follows:—

> Gold-bearing quartz veins were found on Island Mountain in the early 1870's, and in 1878 the Enterprise Company, a group of Barkerville miners, began exploration work on them. This company intended to haul ore to a 10-stamp mill installed in the Kurtz and Lane shaft-house at the Meadows. The Island Mountain Quartz Mining and Milling Co. took over the ground in 1887, moved the mill from the Meadows to Jack of Clubs Lake (near the present mill location), and, assisted by a loan of $20,000 from the British Columbia Government, built a new mill. Several hundred tons of ore, mainly from the Johns adit, was milled in 1890, and 15 to 20 tons of pyrite concentrates was shipped to the Government Reduction Works at Barkerville for treatment.
>
> A satisfactory recovery of gold could not be made, and the property was forfeited to the Government for non-repayment of the loan. No further work was done until 1897, when the same company leased the property from the Government, installed four vanners, and ran the mill for about a month, again unprofitably. In 1903 the late C. J. Seymour Baker tested ore from Island Mountain and cleaned out some old adits, but interest in the property again lapsed. In 1925 Baker acquired the five original Crown-granted mineral claims, later known as the Aurum group, from the Government and each year until 1932 employed a small crew clearing out the old workings. In 1932 he optioned the Aurum group of five claims to Reward Mining Company Limited, who located eight adjoining claims to the west. This company bonded the whole property to Cariboo Consolidated Gold Mines Limited, who in turn optioned their holdings to Newmont Mining Corporation of New York. Island Mountain Mines Company Limited was incorporated by that corporation to operate the property.
>
> About 1,000 feet of underground work was done during early exploration. Although several hundred tons of ore was milled, there is no record of the amount of gold produced. Production by Island Mountain Mines Company began in November, 1934, with a 50-ton mill. The mill capacity was increased to 100 tons per day in 1935, and production has been continuous to the present.

To the end of 1953 the mine produced 740,525 tons of ore, from which 320,792 ounces of gold and 46,502 ounces of silver were recovered, yielding $12,065,682. In August, 1954, the mine and property, excluding the mill and some buildings, were sold to The Cariboo Gold Quartz Mining Company Limited for $300,000. The 1954 production up to the date of sale amounted to 30,584 tons, from which approximately 13,000 ounces of gold and 1,400 ounces of silver were recovered. Dividends declared total $1,517,283. Island Mountain Mines Company Limited is in process of voluntary liquidation and the estimated assets of the company total $911,000.*

The mine workings are extensive, totalling more than 20 miles. The portal of the main haulage adit (4000 level) is situated near the northeast corner of the Aurum claim and approximately 80 feet above Jack of Clubs Lake. From this level, 1,500 feet from the portal, a vertical three-compartment shaft provides access to the eleven deeper levels. The interval between levels is 125 feet down to the 3000 level and thence 150 feet to the lowest level (2550). From the shaft stations the main development extends to the

* Initial liquidating payments of 85 cents per share were paid up to November 30th, 1955.

northwest and southeast, approximately parallel to the regional strike. Above the main haulage level are several old adits, of which the Mid Lake (4230) is much the longest. Shorter ones include the Upper Lake (4350), Lower Johns (4480), and the Upper Johns (4510).

The mine workings are almost entirely within the Snowshoe formation but are also in the Midas formation. Most of the workings are restricted to a relatively thin stratigraphic section of the Snowshoe formation.

The detailed startigraphy cannot be outlined with certainty because the structure is not known in detail. The problems are treated in the discussion of the geology of the Wells camp on page 53 and will be only briefly reviewed. Figure 12 portrays diagrammatically the interpretations of the stratigraphy and structure at Island Mountain according to (*a*) Hanson, (*b*) Benedict, and (*c*) the writer. The sections are shown looking northwest at the shaft. The writer recognizes an attenuated isoclinal syncline at Island Mountain mine, and names it the Sanders syncline.

The following table presents in simplified form the sequences of rocks encountered from the base of the Snowshoe formation toward the northeast, without regard to possible duplication by folding:—

Regional Unit	Lithology	Approximate Thickness in Feet	Mine Nomenclature	
Snowshoe formation.	Limestone and limy phyllite.	0–100	Johns limestone beds.	Baker member.
	Micaceous quartzite and phyllite.	400		
	White and grey limestone, green or brown phyllite, and ankerite-chlorite rock.	0–80	Baker limestone beds.	
	Grey micaceous quartzite and phyllite.	400–600		Rainbow member.
	Argillacenus limestone.	0–60	309 limestone beds.	
	Grey phyllite and micaceous quartzite.	200		
Midas formation.	Black or bleached argillite or phyllite.		B.C. member.	

The mine stratigraphic nomenclature cannot be completely revised until the structure is fully mapped. The names " Rainbow " and " Baker " members may continue to be used, although they have no meaning in the larger setting. The three thin limestones probably represent one stratigraphic horizon repeated by isoclinal folding, but they can still be called the 309, Baker, and Johns limestones until this is proved or disproved.

The Midas formation is formed entirely of black argillite and phyllite, either of which may be bleached. The formation is not repeated by folding within accessible mine workings. The Snowshoe formation is composed dominantly of lenticular beds of micaceous quartzite and phyllite, and minor limestone and limy phyllite.

The three limestones have relatively great continuity, but all pinch and swell in the direction of plunge and also have been thickened on crests and thinned on limbs by flowage during folding. The Baker limestone beds have the greatest continuity on strike and dip. Commonly these beds are composed of white limestone, but interlaminations of light green or fawn phyllite may make up much of the thickness. Rarely the limestone may be grey and argillaceous and the phyllite grey. Such rock is not commonly mineralized. The 309 limestone is continuous and relatively thick in the upper levels of the mine but is thin and discontinuous in the lower levels. It is commonly grey and argillaceous. The Johns limestone is little explored, and knowledge of it comes mostly from rare surface exposures and diamond-drill holes.

A green rock composed of chlorite, quartz, and ankerite occurs immediately northeast of the Baker limestone beds. Although this rock appears to be parallel to the bedding, it may have crosscutting relationships. It is termed " diorite " at Island Mountain mine and " tuff " at Cariboo Gold Quartz mine. Simil r rocks are known to be highly altered Mount Murray diabases, so that the term " altered diorite " may not be far amiss.

Both Midas and Snowshoe rocks have been bleached locally. Midas phyllites bleached to biscuit colour are present on the lowest level of the mine. Their origin is betrayed by penetration of bleaching along foliation and AC joints and by ragged kernels of unbleached rocks within bleached ones. Snowshoe phyllites and quartzites have locally been bleached, and possibly much of the Baker limestone beds and associated phyllites have been recrystallized and bleached. Locally the quartzites have been silicified. Other alterations are rare.

The stratigraphy at Island Mountain mine may be compared with that at the Cariboo Gold Quartz mine. The section between Midas formation and Baker limestone is thinner in the Cariboo Gold Quartz mine. Bleached rocks and the phyllite with quartzite lenticles are sparingly present in Island Mountain mine. The greatest difference is in the amount and type of limestones. In the Cariboo Gold Quartz mine the Baker limestone may be dark grey and argillaceous, and there is essentially no equivalent of the 309 limestone of Island Mountain mine although about a foot of limestone is found in the 201 crosscut.

The main fold structures of the mine consist of the Sanders syncline and the mine dragfold (*see* Figs. 8 and 12). The Sanders syncline cannot be directly observed but is the simplest interpretation of the known facts. All folds plunge northwestward at an average of 22 degrees. On the surface near the northwestern boundary of the property the plunge is reduced to 2 to 5 degrees northwestward.

The Sanders syncline lies between the mine dragfold and the Island Mountain anticlinorium. The dragfold shows that the Baker limestone beds are overturned and lie between a syncline to the southwest and an anticline to the northeast. The Midas formation is right side up on the northeastern flank of the Island Mountain anticlinorium and, therefore, a syncline must exist between it and the dragfold. The next anticline northeast of the mine dragfold is small compared to the Island Mountain anticlinorium and no Midas rocks outcrop at the surface. The syncline and anticline are part of a series of folds between the Island Mountain anticlinorium and the Snowshoe synclinorium.

Figure 21 shows the mine dragfold on the 3500 level, outlined by Baker limestone beds. The dragfold has a wave-length of about 400 feet. The pure limestone is found in large lenticles that are not features of original deposition. The limestone has flowed, been pulled apart, and been torn by small faults. Although discontinuous, the limestone and phyllite together clearly trace the outline of the dragfold. In contrast, structures are obscure in the micaceous quartzites, as Figure 21 shows. In these rocks there is no indication of the position of the synclinal axis of the dragfold and no evidence of closure.

Minor folds are very numerous. Where outlined by limestone they are readily apparent, but in adjacent micaceous quartzite the folds may not even be recognizable (*see* Plate VIII (B)). In the central limb of the mine dragfold some minor folds are recumbent. Such folds have not been observed elsewhere in the area.

The major faults in the mine are the Aurum and Jack of Clubs. The Mosquito Creek fault cuts through the property but is not exposed in the mine. Benedict (1945, p. 762) described the Aurum fault as follows:—

> Over much of its underground exposure it strikes N. 20° to 30° W. and dips about 40° to the east. It is relatively regular. Its displacement is variable. At one point, the hanging-wall has moved S. 59° E. a distance of which the horizontal component is 475 feet and the vertical component is 240 feet down. In plan it offsets to the right, though, due to folding of the rocks, this is not very obvious. The writer believes it carries both pre- and post-mineral movement, and that considerable ore quartz was deposited along it.

In the lower levels of the mine the Aurum fault flattens, is narrower, and has less movement. The strike of the Aurum fault is slightly different from that of most major faults in the map-area, but the resultant movement, described by Benedict, trends south 59 degrees east, and hence is little different from that of most faults striking north 10 to 20 degrees east.

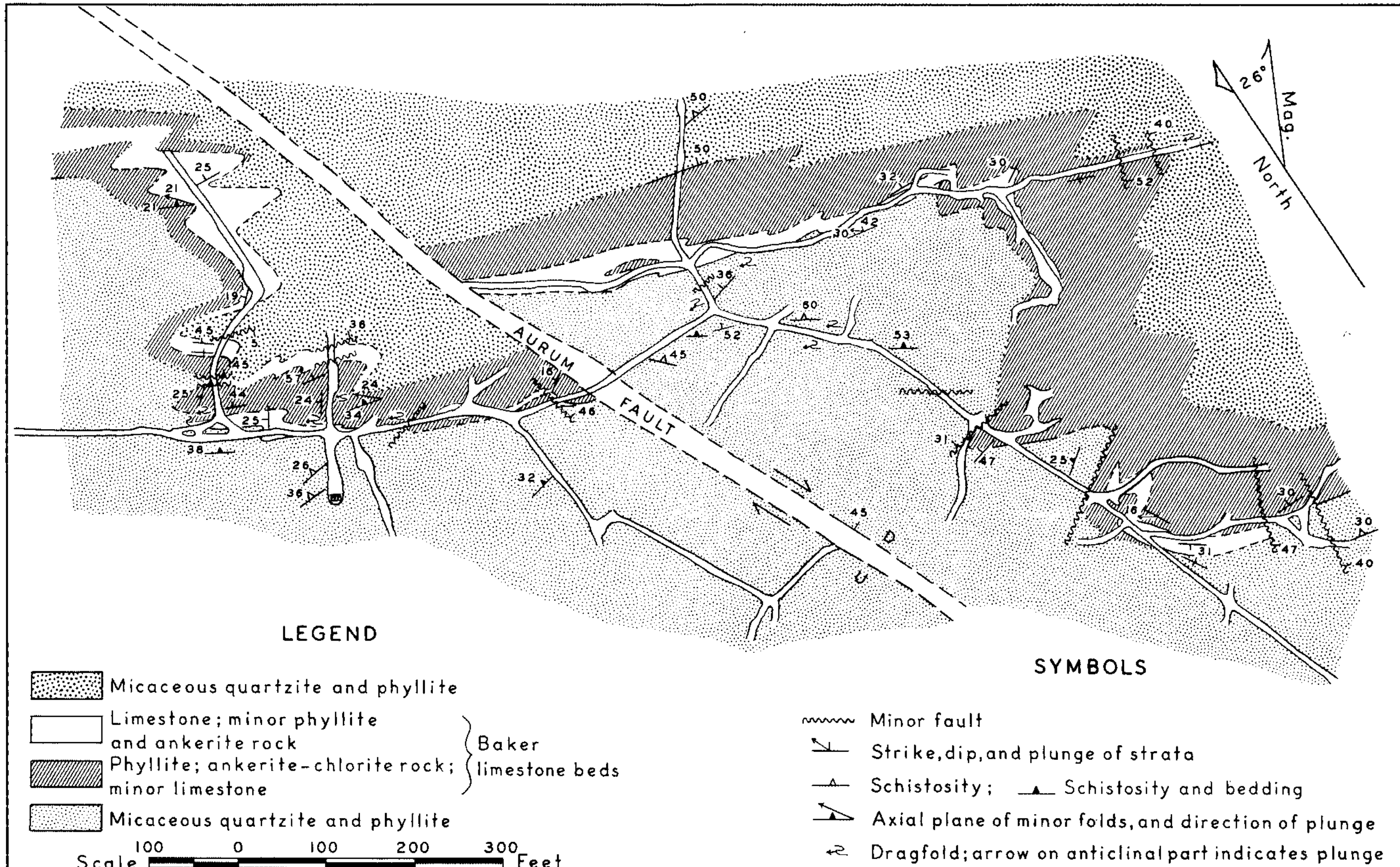


Figure 21

PART OF 3500 LEVEL-ISLAND MOUNTAIN MINE

Showing major dragfold plunging northwestward at approximately 22°

NOTE: Structural information in the quartzites is obscure or misleading

The property is adjacent to the richest placer stream of the district and was prospected for lode as early as 1864 by Wilkinson, who found the Proserpine vein. Prospect shafts were sunk in several strike veins, including the Proserpine and Steadman. Activity lapsed until 1906, when C. J. S. Baker started prospecting in the vicinity and located the central claims of the group. Little was done from 1914 until 1933, when Newmont Mining Corporation drove a shallow adit 975 feet on the Proserpine South (Lot 431). The group has since received little attention.

The claims are underlain by rocks of the Snowshoe and Midas formations. The Midas formation underlies the Pani South (Lot 10591), and most of the North Star (Lot 10593), Pani (Lot 10590), San Juan (41F), and San Juan Extension (Lot 10592). The Midas formation is chiefly black argillite and metasiltstone with lesser amounts of phyllite or bleached argillite. Exposures in the placer pit on Mink Gulch show patchiness and gradation of bleached and unaltered rocks. The Snowshoe formation is very poorly exposed and can only be seen along the road to the Warspite adit and in some surface stripping. The formation is composed of grey micaceous quartzite, siltstone, and phyllite, with lesser amounts of brown phyllite and minor limestone.

The Midas formation is exposed from one contact with the Snowshoe formation along Williams Creek and Mink Gulch to the other Snowshoe contact near Walker Gulch in a series of overturned folds which are part of the Island Mountain anticlinorium. The folds along Williams Creek are sharp and attenuated, whereas those on upper Mink Gulch are on the crest of the anticlinorium and are less sharp and of smaller amplitude. The combination of topography and complex overturned folds lends the trace of the contact with the Snowshoe formation a complicated yet nearly flat-lying form. For additional details of the fold structures at either side of the Island Mountain anticlinorium in the vicinity *see* " Westport " and " Richfield." Because of a dearth of outcrop, little can be seen of the folding within the Snowshoe formation. The chief fault within the property is the Barkerville (described on pp. 56 and 92). Several other northerly striking faults are known but are too small to be shown on Figure 2.

The Proserpine is the most prominent vein, a strike vein that can be traced from the Wilkinson (Lot 177) several hundred feet southeast to the Proserpine (Lot 430). It appears to be nearly barren. A number of transverse and diagonal veins have been exposed by surface stripping, and some are well mineralized with pyrite. The adit on the Proserpine South claim was not examined by the writer. Hanson (1935, p. 31) described it as follows:—

> In 1933 Island Mountain Mines Company, Limited, drove a crosscut adit from the Proserpine South claim eastward under this group of surface openings. The adit is 975 feet long. It is a crosscut to the east for 600 feet and from the end of the crosscut is mainly drift to the north-northeast under the north-western part of the surface openings. The easterly drive cut a few small bed veins. The northerly drive disclosed one quartz-pyrite vein at least 6 feet wide striking north 30 degrees east and branch veins 2 feet or less in width also mineralized with pyrite. This vein is disturbed by a fault roughly parallel to it, but appears to pinch to the north to several branching quartz-pyrite veins each 1 foot or less wide that strike north 20 to 30 degrees east and end at an easterly striking fault near the north end of the workings. This vein has been drifted on for 140 feet.

[References: Johnston and Uglow, 1926, pp. 195–201; Hanson, 1935, pp. 31–32; *Minister of Mines, B.C.*, Ann. Rept., 1914, p. 66.]

Richfield
[14]

The Richfield property was explored during 1933–34 by Richfield Cariboo Gold Mines Limited, which was dissolved in 1948. The claims have lapsed. The Richfield adit at the head of Mink Gulch is driven into the base of the northern spur of Bald Mountain at approximately 5,055 feet elevation. The adit is 2,810 feet long, being driven 600 feet from the portal south 52 degrees east, then 1,950 feet due south, and finally 260 feet averaging south 55 degrees west. The adit was driven to intersect the downward projection of a group of veins exposed on the northern slope of Bald Mountain at approximately 5,700 feet elevation. The surface showings consist of numerous moderately large diagonal and strike veins, all of which are relatively barren of sulphide minerals or solution cavities.

The country rock at the surface showings and extending downward almost to the adit is grey micaceous quartzite of the Snowshoe formation, but the adit is driven entirely in the uppermost part of the Midas formation. Most of the rock in the adit is dense black argillite, but there are some zones of bleaching and some of intense ankeritic alteration. The ankeritic alteration where most intense completely changes the appearance of the rock, so that at first glance it looks igneous.

Only a relatively thin stratigraphic section is exposed because the beds dip gently and are repeated by minor folding. With rare exceptions the folds plunge 10 to 15 degrees northwestward. It is possible that a fault occurs near the portal, because the outer 150 feet of the adit is heavily timbered, but in the remainder there are only very minor faults. A number of small veins occur that are parallel with bedding, but there are also a few 8-inch-wide diagonal veins dipping steeply northward at about 800 feet from the portal. A sample of a bedded quartz vein 1,050 feet from the portal assayed *nil* in gold and silver.

[References: Hanson, 1935, pp. 38–39; *Minister of Mines, B.C.*, Ann. Rept., 1934, pp. C 25–26.]

Shamrock and Myrtle [6]

The Shamrock property, including the former Shamrock and Myrtle groups, consists of nineteen Crown-granted claims and fractions on Barkerville Mountain, chiefly north and west of the village. It is owned by Island Mountain Mining Company Limited and was not included in the sale in 1954 to The Cariboo Gold Quartz Mining Company Limited. The group is bounded by property of The Cariboo Gold Quartz Mining Company Limited and Williams Creek Gold Quartz Mining Company Limited. The only major underground working is the Shamrock adit, driven west for more than a mile from the portal on the outskirts of Barkerville.

The area is largely mantled by drift, and few, if any, veins were found prior to the intensive prospecting by E. E. Armstrong on the Myrtle group in the early 1920's. In 1924 Armstrong milled the oxidized portions of veins discovered by him. In 1933 Newmont Mining Corporation did some stripping on the Myrtle group and Shamrock Gold Mines Limited drove the Shamrock adit 1,800 feet toward the downward projection of some veins on the surface of that group. In 1941 Island Mountain Mines Company Limited purchased the Myrtle and that part of the Shamrock group which included the adit, and in 1941–42 drove the adit to the Martha (Lot 10508) and Cariboo (Lot 10512) claims, over a mile from the portal.

The property is underlain chiefly by the Snowshoe formation, and only near the southwestern boundary of the Myrtle and Marie claims does the Midas formation outcrop. The Snowshoe formation includes grey micaceous quartzite, particularly near the base, and much micaceous siltstone and phyllite, and moderate amounts of limestone near the portal of the adit. The black argillites of the Midas formation outcrop on the northeastern limb of the small anticline, the southwestern limb of which contains the B.C. vein. Northeast from the anticline of Midas rocks there is a series of folds culminating in the Snowshoe synclinorium, the axis of which is northeast of the Shamrock adit. The major faults are the Sirius and Barkerville faults (*see* pp. 56 and 92). The Sirius fault crosses the Shamrock adit close to the Sirius claim.

The surface showings on these three claims appear as encouraging as any on the Cariboo Gold Quartz or Island Mountain properties. A large number of transverse and some diagonal and strike veins were uncovered on the three claims by E. E. Armstrong in 1920–24. The values obtained in the oxidized portions of these veins were encouraging, and below the oxidized zone the veins were reported to be highly pyritiferous.

The Shamrock adit was inaccessible and could not be examined by the writer. The adit was driven toward the Martha (Lot 10508), Marie (Lot 10502), and Myrtle (Lot

10501) claims but did not reach the latter two. Many transverse veinlets were encountered on the southwest side of the Martha claim.

[References: Hanson, 1935, pp. 26, 28; *Minister of Mines, B.C.,* Ann. Rept., 1924, p. 117; 1925, p. 149; *B.C. Dept. of Mines,* Bull. No. 1, 1932, p. 62.]

Warspite, Independence, Hard Cash, etc. (Proserpine Mines Limited) [11] [12] [13]

The Warspite (Lot 9560), Hard Cash (Lot 9564), and Independence (Lot 9563) are three of the most important of a group of forty-one Crown-granted claims and fractions on southeastern Mount Proserpine and northwestern Antler Mountain. The property is owned by Proserpine Mines Limited, which is controlled by Pioneer Gold Mines of B.C. Limited through Barkerville Mining Company Limited. Mount Proserpine was one of the localities first prospected, but little was done on the area of the present property except the exploration of some veins at the head of Grouse Creek, where several small adits were driven. The first intensive work was done by E. E. Armstrong, who located the Independence in 1916 and other claims to the southeast thereafter. In 1917 Tregillus, Blair, and Carey located the Kitchener (Lot 10558), Warspite, and other claims covering the ground between the Proserpine group and the Independence. Both groups of claims were optioned in 1919 by Mining Corporation of Canada Limited, which did some exploratory work but dropped the options the following year. Only minor work was done until 1933, when the same claims were optioned by the Proserpine Syndicate, directed by W. R. Wilson and Sons. Small adits were driven on the Warspite and Independence claims. In the same year Premier Gold Mining Company Limited did some surface stripping on claims on Antler Mountain which are now part of the group. In 1934 the Proserpine Syndicate incorporated as Proserpine Gold Mines Limited and did more surface and underground work, particularly in the Bell and Newberry adits on the Independence claim. In 1939 the company drove an adit more than 1,000 feet long on the Hard Cash claim from Grouse Creek. In 1940 Privateer Mine Limited optioned the Proserpine Gold Mines Limited holdings and did 36,000 feet of bulldozer and hand stripping, and some underground work in the Warspite adit. In 1945 Proserpine Mines Limited succeeded the former company, and twenty-one claims (Rex, Elsie, and Hen groups) were recorded northeast of the Crown-granted claims. In 1945–46 approximately 54,000 lineal feet of bulldozer stripping and road-building, 900 feet of drifting in the Warspite adit, and 1,700 feet of diamond drilling were done. No work has been done since, and most of the recorded claims have lapsed.

The main underground workings are the Warspite [11], Hard Cash [13], and Bell and Newberry [12] adits, the last two being on the Independence claim. With the exception of the Hard Cash, the adits are situated on the upland slopes of Mount Proserpine and intersect earlier shallow prospect shafts. The Warspite adit has about 1,400 feet of workings, the Hard Cash 1,025 feet, the Bell 700 feet, and the Newberry 600 feet. A branch from the Cariboo Hudson road at Conklin Gulch leads to the Warspite adit, whence bulldozed strips lead to the other two adits on Mount Proserpine. A road leads up Grouse Creek from the Hudson road to the Hard Cash adit, but the last three-quarters of a mile is impassable by car.

The property is underlain dominantly by the Snowshoe formation, including grey micaceous quartzite and phyllite with lesser amounts of brown or green phyllite and minor limestone lenses. There is slightly less micaceous quartzite than is common in the lower part of the Snowshoe formation. At the head of Grouse Creek a phyllite with quartzite lenticles similar to that described in the Cariboo Gold Quartz mine indicates intense deformation, probably by extensive thinning and pulling apart of beds. The Midas formation outcrops along the southwestern boundary of the property. A number of Proserpine acidic dykes occur and several zones of silicification.

Fold structures are not clear in detail. Many minor folds are clearly recognizable but only one large fold, the Island Mountain anticlinorium. Midas formation outcropping in the southwestern part of the property forms part of the northeastern flank of this structure. On the property all folds plunge northwestward from 5 to 15 degrees.

Mount Proserpine lies between two major northerly striking faults, the Barkerville fault on the west and the Grouse Creek fault on the east. The Barkerville fault is discussed an pages 56 and 92. The Grouse Creek fault in the vicinity of the claims follows the deep cleft of Grouse Creek. The fault undoubtedly dips steeply eastward and has been subject to normal movement, which has produced a right-hand horizontal separation of approximately 800 feet. When the trenches were fresh, C. E. G. Brown, geologist for Proserpine Mines Limited, mapped many small faults, mostly northerly striking ones. These faults are too small to indicate on Figure 2. Several small faults are seen in the adits. One slip in the Warspite adit strikes subparallel with the bedding but dips more steeply.

Veins on Mount Proserpine are described in some detail by Johnston and Uglow (1926, pp. 195–205). The great amount of bulldozer stripping carried out since then has uncovered very few veins that were not known previously. Veins of all types common in the district occur on Mount Proserpine, the larger ones being strike veins. The veins contain more galena than is common in the area, but not in amounts to make the veins of interest as a source of lead. The galena is not argentiferous.

The Warspite adit [11] is near the north corner of the Warspite claim at approximately 5,525 feet elevation. The adit crosscuts the strata at north 51 degrees east for 120 feet, and then turns southeastward and follows the strata at an average of south 53 degrees east for over 1,000 feet. A branch 320 feet from the portal follows a silicified zone for 150 feet to the east. A shaft 34 feet deep is intersected by the drift 160 feet from the portal. The workings expose about 200 to 300 feet of strata, of which the northeastern part is largely micaceous quartzite with interbedded phyllite and the southwestern part largely phyllite. Foliation strikes on the average north 57 degrees west and dips 60 to 80 degrees northeastward. The bedding, where it can be distinguished, is parallel to the cleavage.

There are two major strike veins and, particularly in the first 500 feet of workings, numerous small transverse veins and veinlets. The most interesting vein, well mineralized with pyrite, is a strike vein exposed in the shaft, crosscut, and drift. It is 130 feet long and averages about 1 foot wide. It strikes north 60 degrees west and dips 60 degrees northeastward. The other strike vein occupies a small fault which is subparallel with bedding and which, where quartz-filled, strikes north 34 degrees west. This vein is first seen in the drift 470 feet from the portal and continues for 120 feet. It is 1 to 3½ feet wide. The vein is locally well mineralized with pyrite. Two samples taken at average parts of the vein assayed as follows:—

Location	Width	Gold	Silver
	Feet	Oz. per Ton	Oz. per Ton
1. 525 feet from portal	2	0.1	*Nil*
2. 590 feet from portal	3½	*Nil*	*Nil*

A zone of silicified and bleached quartzite 30 to 40 feet wide and subparallel to the schistosity is encountered by the drift and followed by a branch. The zone has been traced by drilling for 400 feet. Small transverse veinlets occupy the AC joints within the zone of alteration and are very numerous and commonly pyritiferous. The altered rock itself has some pyrite in it. A selected sample of the altered rock from drill core assayed: Gold, 0.10 ounce per ton. A sample across a well-mineralized transverse vein 8 inches wide 395 feet from the portal assayed: Gold, 0.67 ounce per ton.

The Bell and Newberry adits [12] on the Independence claim could not be examined because the portals were caved and ice-filled. The Bell adit is reported to be 700 feet long in a southwesterly direction. Hanson (1935, pp. 32–33) reported the adit intersects two 8-foot-wide strike veins which are both well mineralized, and picked samples of pyrite from them reportedly assayed 4 ounces of gold per ton. The portal of the Newberry adit is near the boundary of the Hard Cash claim. The adit is 600 feet long and, according to Hanson (1935, p. 33), "it cuts two quartzose zones, each about 30 feet wide, of bed vein type, locally well mineralized with pyrite."

The Hard Cash adit [13] is driven westward from the bank of Grouse Creek at approximately 4,850 feet elevation for over 1,000 feet through grey micaceous quartzites and phyllites and one silicified and bleached zone 80 feet wide. Apart from two small diagonal veins near the face, the only veins are near the portal, where there is an irregular group of transverse and diagonal veins sparsely mineralized with pyrite and galena. A sample across a narrow diagonal vein 8 inches wide, 50 feet from the portal, assayed: *Nil* in gold and silver.

[References: Johnston and Uglow, 1926, pp. 195–206; Hanson, 1935, pp. 32–33; *Minister of Mines, B.C.*, Ann. Rept., 1917, pp. 128–130; 1918, pp. 131–135; 1934, p. C 24; 1946, pp. 91–93.]

Westport (Williams Creek Gold Quartz Mining Company Limited)
[7] [8] [9]

The Westport group comprises twenty-eight claims and fractions at the confluence of Stouts Gulch and Williams Creek. It includes four of the oldest lode claims in British Columbia—the Black Jack (Lot 1B), Wintrip (Lot 32F), Homestake (Lot 4B), and Cornish (Lot 1F). Other claims in the group which have been described separately in earlier reports are the Morning Star (Lot 10504), Evening Star (Lot 10505), Sirius (Lot 10506), Westport (Lot 10468), Diller (Lot 10503), Black Jack Extension (Lot 10469), and Mammoth (Lot 10472). The property is now held by Williams Creek Gold Quartz Mining Company Limited, which company is owned principally by The Cariboo Gold Quartz Mining Company Limited, Noranda Mines Limited, and Consolidated Quebec Gold Mining and Metals Corporation.

The Westport group includes within it much of the richest placer ground on Williams Creek. Not unnaturally, this was one of the first places prospected for lode deposits, and the Black Jack claim, in particular, has been repeatedly examined since the late 1860's. The chief development on the Black Jack was from 1887 to 1892. During this period a shaft was sunk 120 feet, from which three levels were established with a total of a few hundred feet of drifts and crosscuts. In this period $5,000 to $7,000 in gold was recovered from approximately 300 tons of ore. It was reported that assays of $70 per ton and greater had been obtained from the ore, but milling practice was so primitive that the recovery was of the order of $17 to $23 per ton. The high assays were probably from enriched oxidized upper portions of the vein. Activity lapsed until the 1930's, when the Aladdin-Honest John and Dooley-Home Rule showings on the present Morning Star and Evening Star claims were prospected. In 1933 Britannia Mining and Smelting Co. Limited took options on many of the claims now in the Westport group. This company drove three prospect adits—one each on the Black Jack [9], Westport [7], and Wintrip [8] claims—but dropped the options in 1934. The Cariboo Gold Quartz Mining Company Limited acquired the group in 1938, and in 1946 turned it over to Williams Creek Gold Quartz Mining Company Limited. The present owners rigourously explored the group by geological survey, stripping, and diamond drilling. Approximately 15,000 feet of drilling was done, mostly in the vicinity of the Westport and Black Jack adits, and 10,000 feet of bulldozer stripping was done, mostly on the Morning Star claim. The company has been inactive since 1947.

The Westport group is underlain almost entirely by the Snowshoe formation, only part of the Pilot (Lot 10473) and Morning Star claims being underlain by Midas formation. The Snowshoe formation consists typically of grey micaceous quartzites and interbedded phyllites but includes brown and green phyllites and limestone beds, particularly in the northeastern part of the property.

Fold structures are complicated. The axis of a moderate-sized anticline crosses Williams Creek approximately 1,200 feet southeast of the confluence with Stouts Gulch. This anticline is probably the continuation of the one in which the B.C. shaft is located. A syncline occurs between this structure and the outcrop of Midas formation farther up Williams Creek. The Midas rocks form the northeastern flank of the Island Mountain anticlinorium. All structures are complicated by much dragfolding.

Two major northerly striking faults cross the Westport group. The western fault, the Sirius, crosses the Shamrock adit near the northern corner of the Sirius claim, and a branch of it appears in the Wintrip adit. The fault strikes from north to north 20 degrees east and apparently dips steeply eastward. It appears to be essentially a normal fault, and its right-hand horizontal separation of approximately 800 feet shows it to be a large one. The eastern fault, the Barkerville, is shown on Hanson's map (1935) striking northeastward along Williams Creek at Barkerville. The writer considers that the fault is farther to the east and has a more northerly strike (*see* Fig. 2). Possibly a small branch splays from it in the vicinity of Conklin Gulch and continues up Williams Creek. The main fault is exposed on Williams Creek just above Mink Gulch, and an important branch of it was uncovered in J. J. Gunn's hydraulic pit near Conklin Gulch. The fault strikes from north to north 10 degrees east, dips steeply eastward, and is essentially a normal fault. It has an apparent right-hand separation of more than 1,000 feet. There are a number of lesser faults, of which the bedded Westport fault is the most important. It is exposed at the face of the Westport adit, where it strikes north 65 degrees west and dips 40 degrees northeastward. Skerl (1948a, pp. 42–43) believes the Westport fault is important economically because auriferous veins seem more numerous in the hangingwall. He believes that its intersection with the Barkerville fault would be a particularly favourable area to prospect.

The underground workings consist of the Westport [7], the Wintrip [8], and the Black Jack adit [9], each named for the claim on which it is. The Wintrip adit is on the south bank of Stouts Gulch, 1,200 feet from the confluence with Williams Creek, and contains about 320 feet of workings. The adit exposes many veins and veinlets, most of which are transverse. The largest vein is followed for 80 feet. Skerl (1948a, p. 42) states:—

> (this vein has an ore-shoot 60 feet long) averaging 0.25 oz. (of gold) over 3 ft. A drill hole cut this vein at 55 feet below the surface where it assayed 0.16 oz. over 4.5 ft. In another drill hole at about the same elevation and 100 ft. to the east another vein not known at the surface gave 2.85 oz. over 2.0 ft.

Slough from the walls has backed up water so that the adit is difficult to examine at present.

The Westport adit is in the west wall of the small canyon on Williams Creek 400 feet above the confluence of Stouts Gulch. There are about 260 feet of workings, including two drifts on transverse veins. Skerl (1948a, p. 43) states:—

> (the northwestern vein) averaged 0.37 oz. over 1.0 ft. for 36 ft. Diamond drilling from the surface has disclosed that there is a persistent transverse vein about 160 ft. northwest of the last mentioned vein and on the hanging wall of the Westport bedded fault. Five different holes gave the following intersections, over a vertical range of 70 to 300 ft. below the surface on this vein: 0.2 ft., 0.10 oz.; 0.4 ft., 0.73 oz.; 1.0 ft., 0.42 oz.; 0.8 ft., 1.79 oz.; and 7.5 ft., Tr. True widths are probably 75 per cent of those given.

The Black Jack adit is on the east bank of Williams Creek near the confluence with Stouts Gulch, and has about 160 feet of workings. The portal is adjacent to the caved shaft of the original Black Jack mine. The adit shows numerous veinlets, most of which are transverse. These are most dense near the portal, just inside the adit and on the walls of the small surface cut. Some contain considerable pyrite. The largest vein in the surface cut is 1 foot wide and assayed: Gold, 1.10 oz. per ton. Skerl (1948a, p. 43) states that diamond-drill cores of a transverse vein below this site assayed:—

> 0.36 oz. over a true width of 6 ft. in one hole at 320 ft. below the surface and 0.58 oz. over a true width of 9 ft. in another hole 100 ft. to the southwest at 250 ft. below the surface.

Surface stripping revealed some comparable veins on the Morning Star claim, but diamond drilling beneath the showings was not encouraging.

[References: Johnston and Uglow, 1926, pp. 193–194; Hanson, 1935, pp. 27–30; *Minister of Mines, B.C.*, Ann. Rept., 1946, p. 91; 1947, pp. 113–114; Skerl, 1948a, pp. 38–43.]

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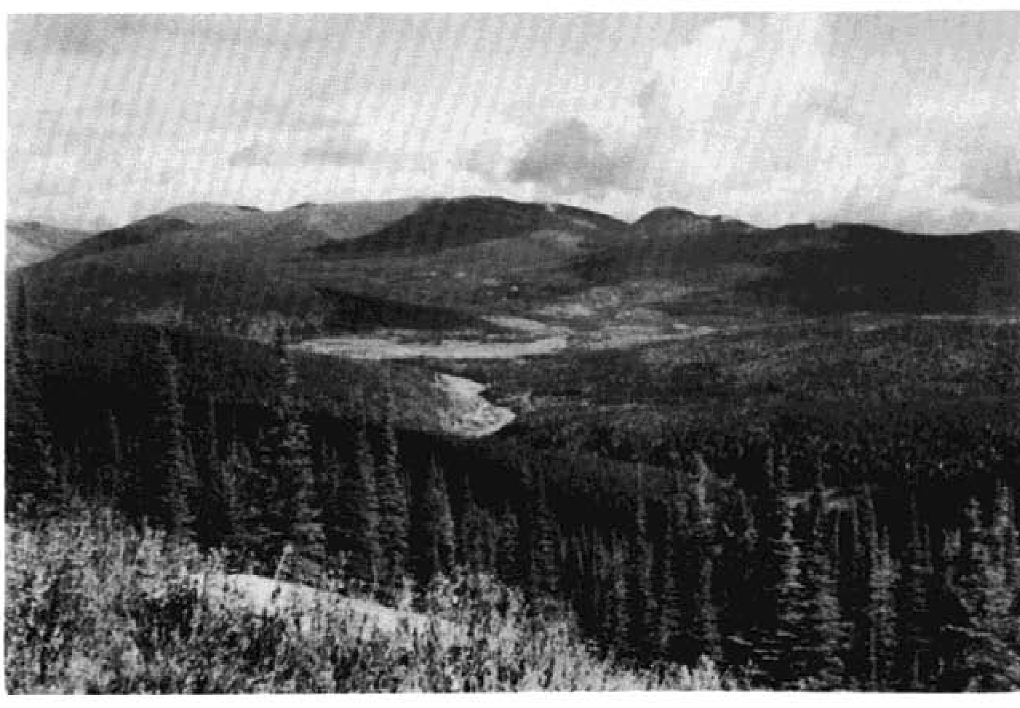
PLATE II

(A) View north from Cow Mountain of Wells; Island Mountain mine in centre, Cariboo Gold Quartz buildings and waste dump right foreground.



(B) View northeast from Richfield Mountain of Barkerville and Mount Murray.

PLATE III

(A) Aerial view east along Lanezi Lake in the Cariboo Mountains, Kaza Mountain left middle ground.

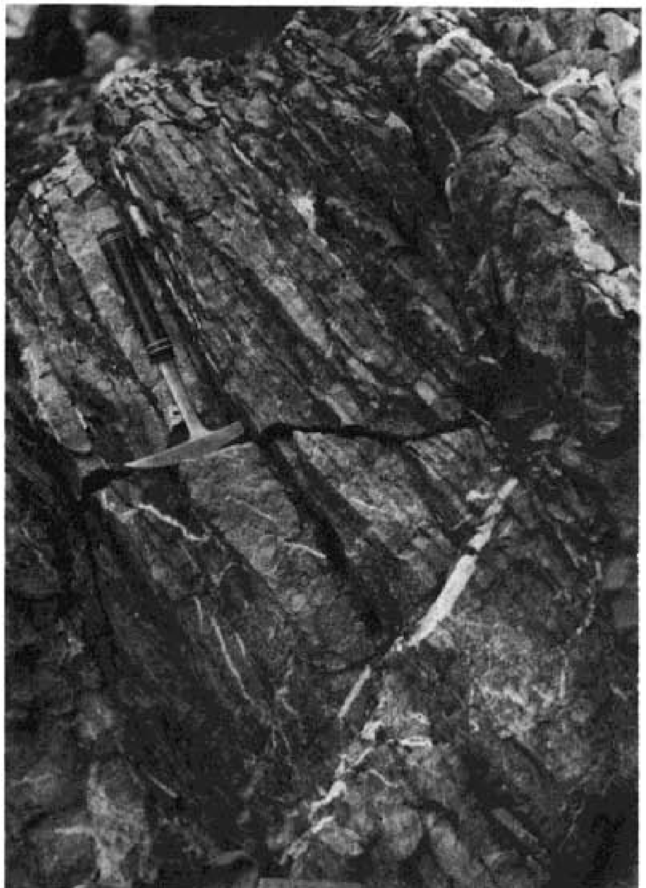
(B) Aerial view west from Spectacle Lakes of Interior Plateau, Antler Creek crosses the photo centre.

PLATE IV

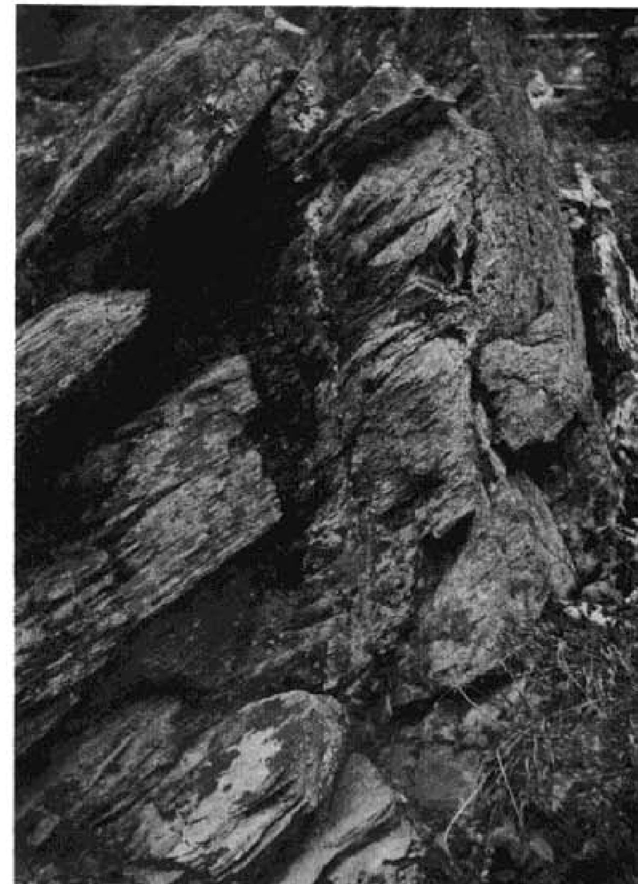
(A) Banding and cross-bedding in lower Midas micaceous siltstone. Banding results from concentrations of ilmenite.

(B) Ankerite porphyroblasts oriented in the schistosity, parallel to the pencil, on a glacially grooved exposure of Snowshoe phyllite.

PLATE V

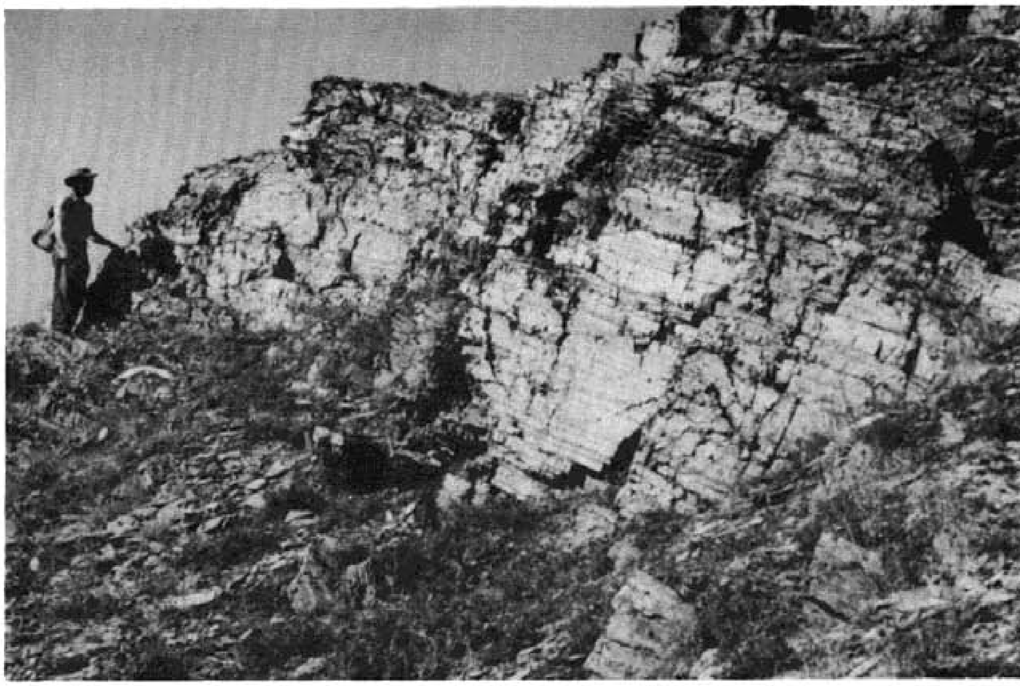


(A) Platy cleavage in Yanks Peak quartzite.



(B) Cleavage bedding relations in Snowshoe micaceous quartzite; cleavage dips 45 degrees to the left and bedding is vertical.

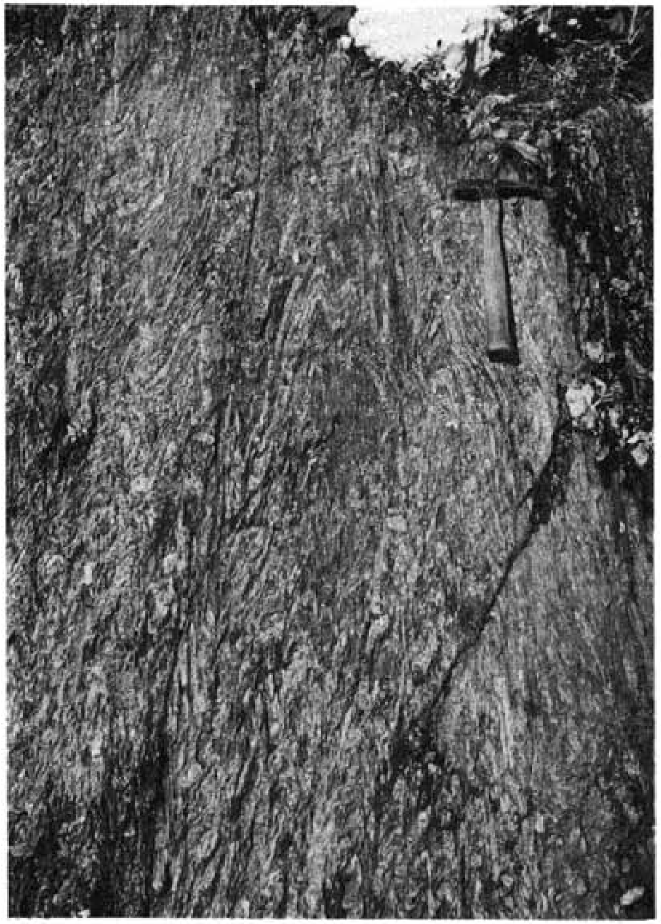
PLATE VI



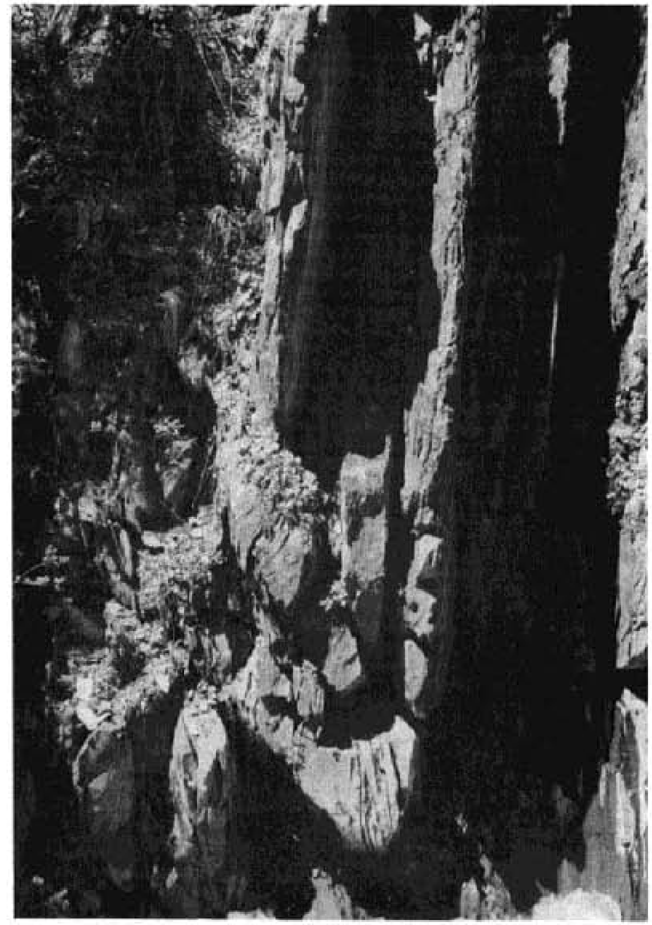
(A) Banded chert and argillite, Antler formation.

(B) Overturned fold of Snowshoe micaceous quartzite on Lowhee Creek.

PLATE VII



(A) Contorted bedding in Midas phyllite, Grouse Creek.



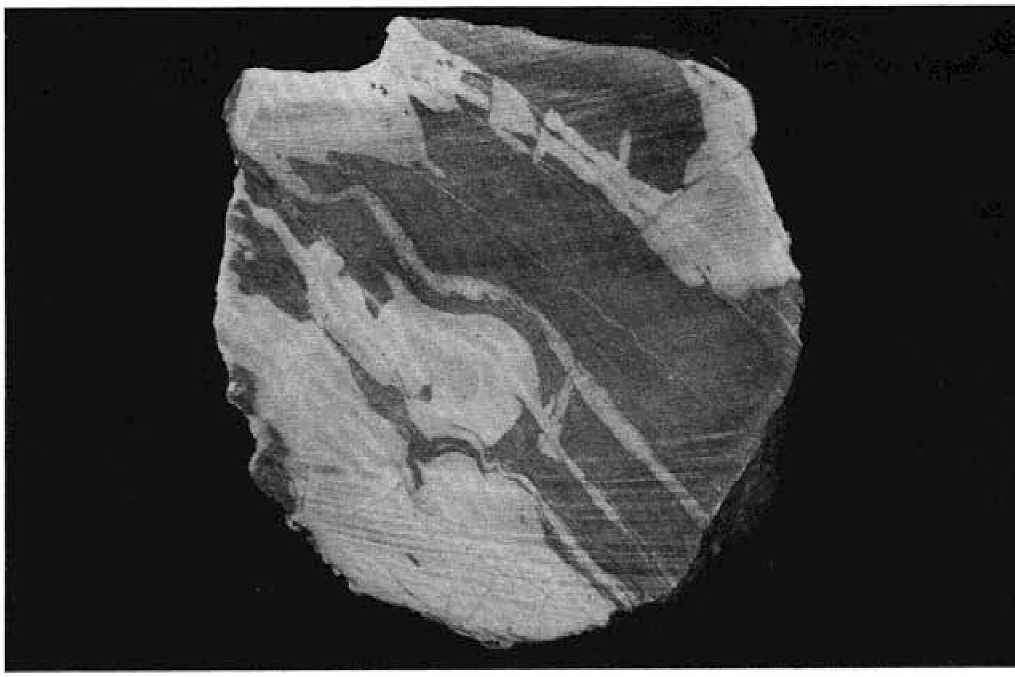
(B) Sharp syncline in Snowshoe micaceous quartzite, Antler Creek.

PLATE VIII

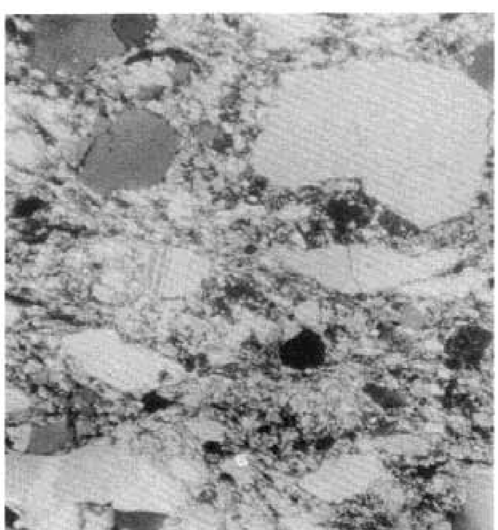
(A) Asymmetric dragfold of Snowshoe metasiltstone.

(B) Folded contact of Baker limestone beds with micaceous quartzites, 3500 level, Island Mountain mine.

PLATE IX



(A) Hand specimen showing bleaching of Midas metasiltstone. Schistosity crosses the specimen from top left to bottom right, saw marks approximately horizontal.



(B) Photomicrograph of relatively undeformed Snowshoe micaceous quartzite from Mount Burdett showing rounded to angular quartz and rare feldspar grains in a matrix of fine-grained quartz and muscovite. Crossed nicols, ×45.

(C) Photomicrograph of flaser Snowshoe micaceous quartzite from Island Mountain showing flattened quartz porphyroclasts in a matrix of fine-grained quartz and muscovite. Crossed nicols, ×6.

APPENDIX A

DESCRIPTION OF THE MICROSCOPIC EFFECTS OF DEFORMATION ON CARIBOO ROCKS

The arenaceous rocks of the Cariboo group show abundant microscopic evidence of intense deformation. Different rock types have been differently affected by the deformation.

The Yanks Peak quartzite is a homogenous rock and the effects are uniform throughout the formation. The original detrital rounded quartz grains are betrayed by smoothly curved lines of dusty inclusions on the outside of which sutures occur in secondary growth. Commonly sericite flakes oriented in an *s*-surface give ragged intertonguing terminations in the *ab*-plane, but the quartz grains are commonly compact with no sutures in the *c*-direction. Not uncommonly there is a noticeable dimensional orientation of quartz grains parallel to the mica. Grains commonly show solution effects, such as one rounded grain impinging on a grain that is now crescentic in section. Stylolites are further evidence of solution. These jagged lines seldom have an amplitude much greater than the grain size of the rock, but they contain a considerable concentration of mica, opaque matter, and detrital heavy minerals. They truncate original detrital grains, and the grains on one side cannot be related to those on the other.

Normally all quartz grains show strain, most show lines of liquid inclusions, and some show lamellæ. The highly strained grains commonly have ruptures bounding parts that show distinctly different orientations. The ruptures can be irregular scallop-like lines or straight lines parallel to the *c*-axis. Lamellæ and trains of liquid inclusions both have a general trend approximately at right angles to the *s*-surface. One grain may contain two or more orientations of lines of inclusions but only one of lamellæ. Some lamellæ are emphasized by dense clouds of sub-microscopic inclusions in bands parallel to the lamellæ. Lamellæ are most prominent when the *c*-axis of the grain is approximately oriented in the *ab*-plane. In addition to the trains of liquid inclusions, there are larger sub-circular inclusions in some grains. These are randomly scattered in the central part of the grain but not within 0.05 millimetre of the grain boundary or of a definite rupture.

The micaceous quartzites of the Snowshoe formation have behaved differently than the pure Yanks Peak quartzite, but the differences are generally of degree, not of kind. The most noticeable difference is that in the micaceous quartzite there is a remarkable lenticularity and a dimensional orientation of large detrital grains as well as of mica. The extreme development is a flaser rock or sub-mylonite but with no noticeable lineation. In such a rock the *a*- and *b*-fabric axes of large quartz and feldspar grains are as much as four or five times as great as the *c*-axis. There is no noticeable or consistent difference in the *a*- and *b*-axes. The *ab*-planes of quartz and mica not uncommonly crossbedding, which is indicated by especially micaceous laminæ. Large detrital grains commonly shelter in their strain shadows a mosaic of tiny clear quartz grains. Like those of the Yanks Peak quartzite, nearly all large quartz grains show strain, most show trains of inclusions, and many show lamellæ. Large feldspar grains are commonly intensely twinned in a peculiar patchy manner.

More commonly than in the pure quartzites, quartz grains are ruptured or recrystallized so that one original grain has many optical orientations. The most extreme case is that of lenticular bundles of quartz grains forming a crudely polygonal mosaic. A bundle contains no interstitial mica although it is wrapped by mica folia, and thus is thought to have been originally one quartz grain that has become granulated and (or) recrystallized. Recrystallization was probably important because the small new grains are not strained. Every gradation occurs from bundles to strained quartz grains with a few ruptures. The manners in which the orientation of parts of one original grain vary from that of the host include several general types: (1) Sharp changes in undulatory extinction which may

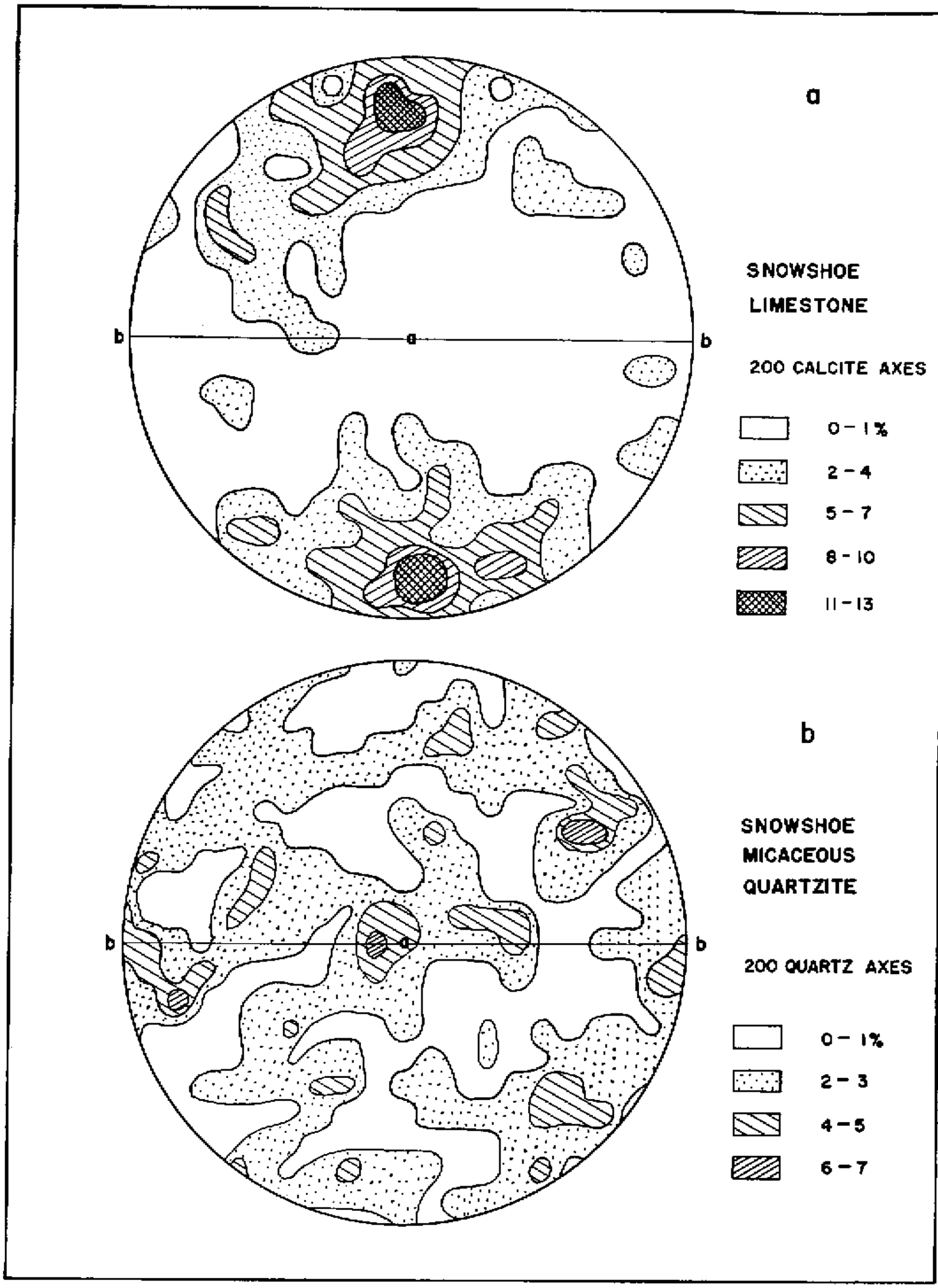


Figure 23. Representative lattice diagrams of Snowshoe formation micaceous quartzite and limestone.

occur along straight lines parallel to the *c*-crystallographic axis (Hietanen, 1938) or in scalloped lines unrelated to crystallographic directions; (2) deformation bands as described by N. A. Riley (1947, p. 468); (3) bands of polygonal quartz which are commonly parallel to deformation bands and appear to be variations or modifications of these bands; (4) whole areas or whole grains granulated or recrystallized to a semi-polygonal mosaic. The shift in optical orientation does not appear to be systematic in (2), (3), and (4) and may range from a few degrees to 90. As in the Yanks Peak quartzite, trains of inclusion are oriented roughly at right angles to the schistosity, and the large rounded liquid inclusions occur in a manner similar to that of the Yanks Peak quartzite.

It is obvious from the diversity of the features that the present fabric is not the result of one process. Solution and deposition, rupture, gliding, and probably rotation have all contributed to the change of fabric. Although proof is lacking, very probably the rotation of detrital grains in the highly micaceous rocks was important. Evidence of other processes is abundant, but relative importance difficult to assess. The gradation from (2) to (3) seems to indicate that rupture followed by recrystallization at the expense of the host was important. The prominent development of lamellæ in both quartz and calcite indicates that translation gliding was also important. In the Snowshoe limestones a marked lattice orientation is developed with *c*-axis maxima approximately normal to the schistosity in which the grains are flattened and markedly lamellar (*see* Fig. 23). This fabric is similar to ones produced experimentally at 300 degrees centigrade in which schistosity is developed at right angles to the compression (Griggs *et al.*, 1953, pp. 1334–1342). In the quartzites, especially the micaceous quartzites, the lattice orientation is either not well developed or is so complex it is not readily interpreted (*see* Fig. 23). It is interesting to note that in a recent article T. C. Phemister and D. H. Williamson (1954) describe a similar flattened fabric in similar quartzites and conclude from the lack of definite lattice orientation that purely mechanical processes have had only minor effect in producing the fabric. In the Antler Creek area and the area described by these authors in Kincardineshire, Scotland, the fabric is unusual, and it is possible that the lack of marked lattice orientation may be related to the unusual fabric.

APPENDIX B

MEASURED AND GENERALIZED SECTIONS OF SLIDE MOUNTAIN GROUP

The Slide Mountain group is poorly exposed, except at localities where conglomerate of the Guyet formation is dominant and on the upper slopes of Mount Murray. A section measured on the northwest slope of this mountain is fairly accurate. Sections at Slide Mountain and farther south on Mount Murray are similar to the measured section on Mount Murray, but even in the short distance between these localities there are notable changes in both formations. For example, on Slide Mountain, only 3,000 feet northwest of the measured section, the Guyet formation contains more volcanic material as cobbles and also contains flows. Two flows (490 to 575 feet and 1,043 to 1,173 feet) in the Antler formation at Mount Murray are absent, and the pillow lava (2,443 to 2,943 feet) is much thinner. The generalized section of Guyet formation at Yellowhawk Creek and Mount Waverly shows that at these localities that conglomerate is rare. The section at Mount Howley is not as accurately measured as that at Mount Murray because it is less well exposed. The Guyet formation at Mount Howley is almost entirely volcanic, yet farther south at Mount Guyet it is again almost entirely conglomerate.

MEASURED SECTIONS OF GUYET AND ANTLER FORMATIONS

Northwest Slope of Mount Murray

	Thickness in Feet	Feet above Guyet Formation
Base of large diabase sill—top of measured section of Antler formation.		
Chert, cherty argillite and argillite; 1- to 2-inch bands, grey, buff, rarely red or green; some fine greywacke; rare algal remains	660	3,603
Basic pillow lava, pillows 1 to 4 feet in greatest diameter; no variation in fabric in pillows, very little interstitial matter	500	2,943
Chert and argillite, banded, buff	165	2,443
Diabase complex sill, dark grey-green, fine-grained, some finely porphyritic; chert rafts and masses common, notable rafts at 95 to 105 feet, 200 to 250 feet, and 420 to 500 feet, contorted at the latter	600	2,278
Diabase sill, medium-grained, dark grey-green	85	1,678
Chert and argillite, 1- to 2-inch bands of chert separated commonly by 1/100 to ½ inch of argillite, partly crumpled	420	1,593
Basic volcanic flow, aphanitic dark grey-green	130	1,173
Argillite, black; some fine greywacke	65	1,043
Quartz-feldspar porphyry sill, silicified	71	978
Argillite, black, with some ellipsoidal cherty knots; some greywacke	70	907
Quartz-feldspar porphyry sill, silicified	39	837
Argillite, black; some ellipsoidal cherty knots; some greywacke	223	798
Basic volcanic flow, aphanitic, flow lines, some areas of massive grey chert	85	575
Argillite, cherty argillite, and banded chert, buff, irregularly cleaved in part, banded rocks near top, partly concealed	490	490
		Feet above Base of Guyet Formation
Guyet formation.		
Chert, white massive[1]	40	1,125
Limestone, white and grey, coarsely crystalline, largely crinoidal; chert nodules and areas[1]	103	1,085
Conglomerate, polymictic, grey to brown, granule to cobble, silicified, some greywacke beds but otherwise massive	982	982
Base—large schistose basic intrusive separates the Guyet formation from the Cariboo group.		

[1] Grade rapidly laterally to conglomerate facies.

Mount Howley

	Thickness in Feet	Feet above Guyet Formation
End of exposure—top of measured section of Antler formation.		
Basic volcanic flow, grey green, carbonatized	----	----
Chert, cherty argillite, argillite, commonly in 1- to 2-inch bands	330	2,445
Gabbro sill, medium-grained, euhedral augite crystals	300	2,115
Basic volcanic flow, poorly exposed	120	1,815
Argillite grading upward to green tuff, poorly exposed	180	1,695
Basic volcanic flow, grey-green, carbonatized	75	1,515
Diabase sill, medium-grained, dark grey-green, many chert rafts	380	1,440
Basic volcanic flow, with grey-green massive chert	20	1,060
Chert and argillite with small chert ellipsoidal particles, grey, banded or irregularly cleaved, poorly exposed	100	1,040
Argillite, buff to grey, massive or irregularly cleaved, some greenstone and chert, the whole very poorly exposed	830	940
"Greenstone"	10	110
Argillite, dark grey, some cherty ellipsoidal particles, irregular cleavage, very finely laminated in part	100	100
		Feet above Cariboo Group
Guyet formation.		
Basic volcanic flows, finely vesicular or amygdaloidal in part, dark grey-green, with up to 30 per cent coarsely crystalline grey calcite in bands roughly parallel with flow bands	160	1,430
Argillite or fine tuff, dark greenish-grey, ankeritic, poorly exposed	200	1,270
Basic volcanic flow, poorly exposed	240	1,070
Basic volcanic breccia, average particle diameter about 4 inches, some vesicular; poorly exposed	300	830
Basic volcanic flow, dark grey-green, flow banding, rare limestone inclusions, poorly exposed	30	530
Covered	500+	500
Base—unconformable contact with Cariboo group covered.		

Generalized Section of Guyet Formation

Yellowhawk Creek

	Thickness in Feet	Feet above Cariboo Group
Base of Antler formation.		
Crinoidal limestone	75	1,175
Basic volcanic flows and pyroclastics; the upper flows contain up to 30 per cent calcite	400	1,100
Argillite and greywacke, grey to brown; some granule conglomerate	400	700
Slate and argillite, grey, moderately schistose in part	300	300
Covered	200	----
Cunningham formation.		

Waverly Mountain

	Thickness in Feet
Base of Antler formation, pillow lava and argillite.	
Greywacke, granule conglomerate, some pebble conglomerate, brown to grey, silicified	200
Argillite and some greywacke, middle grey	450
Basic pillow lava, some inclusions of limestone as much as 2 inches in diameter in pillows	275
Covered, rare exposures of slate, greywacke, or greenstone	1,000
Yankee Belle formation.	

APPENDIX C

CHECK-LIST OF MINERAL CLAIMS OF FIGURE 15

NOTE.—The numbers are lot numbers for Crown-granted claims and registered numbers for located claims.

1B Black Jack Co. (C.G.).
1F Cornish Co. (C.G.).
2B Union Co. (C.G.).
2F Black Bull Co. (C.G.).
4B Homestake Co. (C.G.).
32F Wintrip (C.G.).
41F San Juan Co. (C.G.).
42F Waoming Co. (C.G.).
45F Bonita Co. (C.G.).
47F New Aurora Co. (C.G.).
48F United Co. (C.G.).
92 American (C.G.).
93 Cariboo (C.G.).
94 St. Laurent (C.G.).
177 Wilkinson (C.G.).
301 Goldfinch No. 2 (C.G.).
302 Eagle Fr. (C.G.).
303 Gladstone (C.G.).
318 Goldfinch (C.G.).
356 Pinkerton (C.G.).
423 Champion (C.G.).
430 Proserpine (C.G.).
431 Proserpine South (C.G.).
2044 Proserpine West (C.G.).
2046 Proserpine East (C.G.).
2047 Conklin (C.G.).
2865G Blue Jay.
3215M New Black Bull Quartz.
5862 Olympic No. 5 (C.G.).
5863 Olympic No. 3 (C.G.).
5864 Olympic No. 1 (C.G.).
5865 Olympic No. 4 (C.G.).
5866 Olympic No. 2 (C.G.).
5867 Cariboo No. 7 (C.G.).
5868 Telluride Fr. (C.G.).
5869 Olympic No. 12 (C.G.).
5870 Emma Fr. (C.G.).
5871 Emma (C.G.).
5872 Bull Moose (C.G.).
5873 Snowstorm (C.G.).
5874 Cameron (C.G.).
5875 Cariboo Trail (C.G.).
5876 Apex Fr. (C.G.).
5877 Olympic Fr. (C.G.).
5878 Olympic No. 6 (C.G.).
5879 Olympic No. 7 (C.G.).
5880 Olympic No. 13 (C.G.).
5881 Olympic No. 14 (C.G.).
5882 Olympic No. 11 (C.G.).
5883 Olympic No. 9 (C.G.).
5884 Olympic No. 8 (C.G.).
5885 Olympic No. 17 (C.G.).
5886 Olympic No. 10 (C.G.).
5887 Olympic No. 16 (C.G.).
5888 Olympic No. 15 (C.G.).
5889 Cariboo No. 2 Fr. (C.G.).
5890 Gold Standard Fr. (C.G.).
5891 Bullion (C.G.).
5892 Gold Boom (C.G.).
5893 Gold Standard (C.G.).
5894 Gold Standard No. 1 (C.G.).
5895 Gold Standard No. 2 (C.G.).
5896 Gold Standard No. 3 (C.G.).
5897 Apex (C.G.).
5898 Pinkerton Fr. (C.G.).
5899 Brookford No. 2 (C.G.).
5900 Brookford No. 3 (C.G.).
5901 Brookford No. 4 (C.G.).
5902 Brookford No. 5 (C.G.).
5903 Brookford Fr. (C.G.).
5919 Cariboo Fr. (C.G.).
5924 Red Fr. (C.G.).
7793 Dolly Grey Fr. (C.G.).
7794 Rainbow (C.G.).
7795 Dolly Varden (C.G.).
7796 Lakeview (C.G.).
7797 Jack of Clubs (C.G.).
7798 Telluride (C.G.).
7799 Telluride No. 2 (C.G.).
7800 Telluride No. 3 (C.G.).
7801 Cariboo No. 1 (C.G.).
7802 Cariboo No. 2 (C.G.).
7803 Mother Lode (C.G.).
7804 Rainbow Fr. (C.G.).
7805 Cariboo No. 3 (C.G.).
7806 Goldbrick (C.G.).
7807 Goldbrick Fr. (C.G.).
9442 Roosevelt (C.G.).
9470 Austin Fr. (C.G.).
9560 Warspite (C.G.).
9561 Tipperary (C.G.).
9563 Independence (C.G.).
9564 Hard Cash (C.G.).
9565 Discovery (C.G.).
9569 Blighty (C.G.).
9570 General Currie (C.G.).
9697K Some Bird.
10026 Mucho Oro (C.G.).
10351 Brookford No. 1 (C.G.).
10352 Brookford No. 6 (C.G.).
10353 Brookford No. 7 (C.G.).
10354 Brookford No. 8 (C.G.).
10355 Mosquito (C.G.).
10356 Vancouver (C.G.).
10357 Port Hope (C.G.).
10358 Seattle (C.G.).
10359 Mosquito Fr. (C.G.).
10360 Red Gulch No. 1 (C.G.).
10361 Red Gulch No. 2 (C.G.).
10362 Red Gulch No. 3 (C.G.).
10363 Red Gulch No. 4 (C.G.).
10364 Red Gulch No. 5 (C.G.).
10365 Red Gulch No. 6 (C.G.).
10366 Red Gulch No. 7 (C.G.).
10368 Red Gulch Extension No. 1 (C.G.).
10369 Red Gulch Extension No. 2 (C.G.).
10377 Shamrock No. 4 (C.G.).
10378 Shamrock No. 5 (C.G.).
10379 Shamrock No. 6 (C.G.).
10380 Shamrock No. 7 (C.G.).
10387 Progress No. 8 (C.G.).
10388 Progress No. 7 (C.G.).
10389 Progress No. 6 (C.G.).
10404 Lone Fr. (C.G.).
10420 Pin Money (C.G.).
10467 Snowden (C.G.).
10468 Westport (C.G.).
10469 Black Jack Extension (C.G.).
10470 Blackbird (C.G.).
10471 Royal Oak (C.G.).
10472 Mammoth (C.G.).
10473 Pilot (C.G.).
10474 Mint (C.G.).
10475 Canadian (C.G.).
10476 Armistice (C.G.).
10477 Hoover (C.G.).

10478 Tyee Fr. (C.G.).
10479 Nan Fr. (C.G.).
10480 Meter Fr. (C.G.).
10481 Leeds Fr. (C.G.).
10482 Babs Fr. (C.G.).
10483 Pat Fr. (C.G.).
10484 Tabu Fr. (C.G.).
10501 Myrtle (C.G.).
10502 Marie (C.G.).
10503 Diller (C.G.).
10504 Morning Star (C.G.).
10505 Evening Star (C.G.).
10506 Sirius (C.G.).
10507 Y Fr. (C.G.).
10508 Martha (C.G.).
10509 Mabel (C.G.).
10510 Orion (C.G.).
10511 Florence (C.G.).
10512 Cariboo (C.G.).
10513 Z Fr. (C.G.).
10514 N.M. No. 5 Fr. (C.G.).
10516 Venus Fr. (C.G.).
10517 Aurum (C.G.).
10518 Aurum N.E. (C.G.).
10550 Andy (C.G.).
10551 Amos (C.G.).
10552 Azoic (C.G.).
10553 Aviator (C.G.).
10554 Pre-Cambrian (C.G.).
10555 Porphyry (C.G.).
10556 Tourmaline (C.G.).
10557 True Blue (C.G.).
10558 Kitchener (C.G.).
10559 Gogetter (C.G.).
10560 Kumangetit (C.G.).
10586 Paystreak No. 5 (C.G.).
10587 Paystreak No. 6 (C.G.).
10588 Paystreak No. 7 (C.G.).
10589 Paystreak No. 8 (C.G.).
10590 Pani (C.G.).
10591 Pani South (C.G.).
10592 San Juan Extension (C.G.).
10593 North Star (C.G.).
10595 Boom (C.G.).
10706 A1 (C.G.).
10707 A2 (C.G.).
10708 Production No. 2 (C.G.).
10709 Production No. 1 (C.G.).
10710 Bluebell No. 2 (C.G.).
10711 Bluebell No. 1 Fr. (C.G.).
10712 Bluebell (C.G.).
10713 A3 Fr. (C.G.).
10714 A4 Fr. (C.G.).
10715 A5 Fr. (C.G.).
10716 Consolidated Fr. (C.G.).
10717 Willow No. 7 (C.G.).
10718 Willow No. 8 (C.G.).
10719 Willow No. 9 (C.G.).
10720 Willow No. 10 (C.G.).
10722 Dawne No. 4 Fr. (C.G.).
10723 A6 Fr. (C.G.).
10966 Gold Ridge (C.G.).
10967 Gold Ridge Fr. (C.G.).
10978 Jubitor (C.G.).
10979 Venus (C.G.).
10980 Mercury (C.G.).
10981 Saturn (C.G.).
10982 Mars (C.G.).
10983 Luna (C.G.).
11029 Grouse (C.G.).
11030 Antler (C.G.).
11031 Antler No. 1 (C.G.).
11032 Antler No. 2 (C.G.).
11033 Antler No. 3 (C.G.).
11034 Antler No. 4 (C.G.).
11035 Star Fr. (C.G.).
11036 Nut Fr. (C.G.).
11037 Ant Fr. (C.G.).
11038 Granite Fr. (C.G.).
11039 Xmas No. 1 Fr. (C.G.).
11040 Xmas No. 2 Fr. (C.G.).
11041 Xmas No. 3 Fr. (C.G.).
11042 Xmas No. 4 Fr. (C.G.).
11043 Xmas No. 5 Fr. (C.G.).
11044 Xmas No. 6 Fr. (C.G.).
11045 Penelope (C.G.).
11046 Norah (C.G.).
11047 Luff (C.G.).
11048 Hackle (C.G.).
11049 Ptarmigan Fr. (C.G.).
11050 Tor (C.G.).
11066 Aurum West (C.G.).
11067 Aurum South (C.G.).
11068 Mohawk No. 1 (C.G.).
11069 Mohawk No. 2 (C.G.).
11070 Paystreak No. 1 (C.G.).
11071 Triangle Fr. (C.G.).
11072 Mohawk No. 3 (C.G.).
11073 Mohawk No. 4 (C.G.).
11074 V Fr. (C.G.).
11081 Okay Fr. (C.G.).
11082 Mohawk No. 5 (C.G.).
11083 Mohawk No. 6 (C.G.).
11084 North Star No. 1 (C.G.).
11085 North Star No. 2 (C.G.).
11086 North Star No. 3 (C.G.).
11087 North Star No. 4 (C.G.).
11088 Mohawk No. 9 (C.G.).
11089 Mohawk No. 8 (C.G.).
11090 Mohawk No. 7 (C.G.).
11091 Jim Fr. (C.G.).
11092 Art Fr. (C.G.).
11093 Ivan Fr. (C.G.).
11094 N.M. No. 9 Fr. (C.G.).
11095 Pay Fr. (C.G.).
11222 Tweedsmuir (C.G.).
11223 Triumph (C.G.).
11227 Init Fr. (C.G.).
11229 Princess Fr. (C.G.).
11239 Frenchie (C.G.).
11240 O.I. Fr. (C.G.).
11361 M & M No. 1 (C.G.).
11362 M & M No. 2 (C.G.).
11363 M & M No. 3 (C.G.).
11364 M & M No. 4 (C.G.).
11365 Vera No. 1 (C.G.).
11453 Stephanie Fr. (C.G.).
11454 Noisy Enemy Fr. (C.G.).
15522M 1.
15524M 6.
15527M Stouts.
15528M Stouts Fr.
15627R Hawkeye.
16194N Bud.
16195N Rika.
16431H J.O.K. No. 3 Fr.
16567P Maybe.
16613H Highland.
16614H Bull Fr.
16615H Moses Fr.
16616H Powder Fr.
16749G Rainbow No.1.
16750G Rainbow No. 2.
17077N July Fr.
17257E Canusa No. 1.
17258E Canusa No. 2.
17362H 2.
17363H 4.

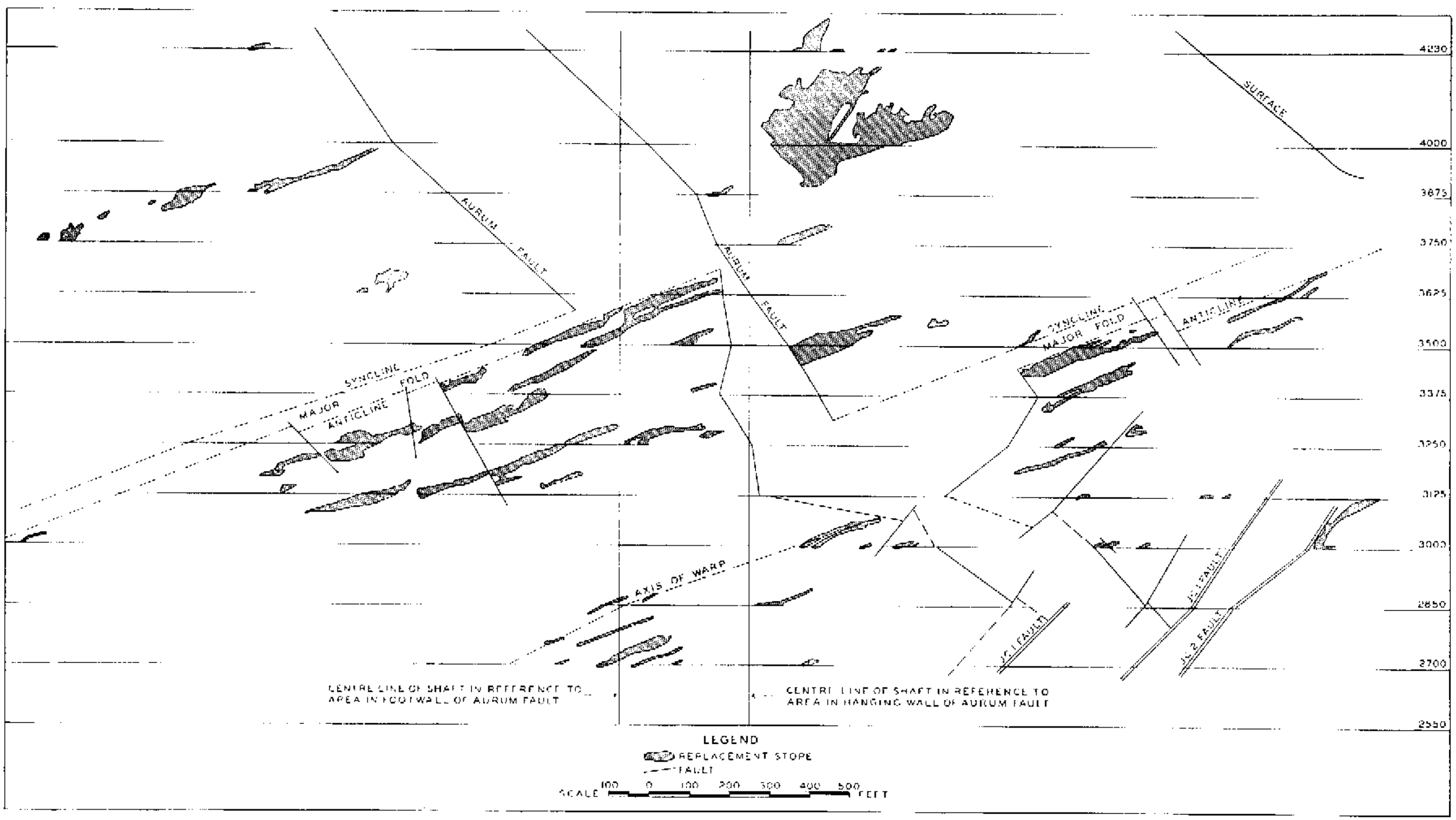


Figure 22. Longitudinal section of Island Mountain replacement stopes (after company plans).

The Jack of Clubs fault is exposed only in the lower levels of the mine along the southeastern boundary. On the 3000 level there are two main strands of the fault 150 feet apart. The fault strikes north 25 degrees east, and, in contrast to most known northerly striking faults, dips steeply northwest and has been subject to reverse movement. However, the separation produced by it is in the same sense as that on the easterly dipping normal faults. The total movement on the fault is unknown and may be much larger than the apparent horizontal separation of a few hundred feet. The Jack of Clubs fault seems to mark a discontinuity between the two mines; the area west of the fault being typical of Island Mountain mine in geology, type of veins, and replacement deposits, whereas the area east of the fault is typical of the Cariboo Gold Quartz mine.

There are numerous small faults in the mine, striking northward, eastward, parallel to the schistosity, and at random. Some flattish faults parallel to the bedding seem related in origin to the folding because they tear minor folds near their crests in a manner consistent with the general interbed movement.

The veins that have been mined are almost entirely diagonal veins that strike north 60 to 80 dregrees east and dip steeply southward. Transverse veins have generally been mined only adjacent to diagonal veins because, in spite of being very numerous, they are too small to be mined alone. East of the Jack of Clubs fault, adjacent to the Cariboo Gold Quartz mine, transverse veins are closely spaced and are mined. Benedict (1945, p. 765) describes the average oreshoot in diagonal veins as 125 feet long, 5 feet wide, and 100 feet on the dip. Such a shoot contains more than 15 per cent of sulphide minerals and constitutes 50 to 100 per cent of the volume of a vein. Commonly the veins are several hundred feet apart. The veins mostly occur in a prism of micaceous quartzite bounded by a fault and a certain distance from the fault (ore-making range) and raking northeastward with the intersection of bedding and the fault. Benedict (1945, p. 769) concluded that it was uneconomic to search for veins more than 600 feet from the footwall or 800 feet from the hangingwall of the Aurum fault because the veins beyond these limits were too scarce to pay for the exploration. In the light of experience at the Cariboo Gold Quartz mine, other northerly faults may be expected to have productive zones associated with them, and recent developments adjacent to the Jack of Clubs fault substantiate this conclusion.

Replacement ore forms about 50 per cent of the mine output. The main source of this ore has been the Baker limestone beds, which have been thoroughly explored. Of late years, ore has been found in other horizons, and replacement ore has been found in the Johns limestone beds and is being mined from two stopes in argillite in the lower levels of the mine. At Island Mountain mine nearly all orebodies are pencil-shaped (*see* Fig. 22). The pencils are mostly localized in the crests of anticlines or, less commonly, in the troughs of synclines and plunge with the folds 22 degrees northwestward. The longest pencil-shaped orebody, 2,000 feet long, is in the anticlinal crest of the major dragfold. Its average cross-sectional area is not much greater than 100 square feet. A few tabular bodies occur in the planar limbs of folds. Replacement deposits consist almost entirely of relatively fine-grained pyrite with a minor amount of arsenopyrite in some bodies. Toward the margins of a deposit the pyrite coarsens and its place is taken by coarse ankerite.

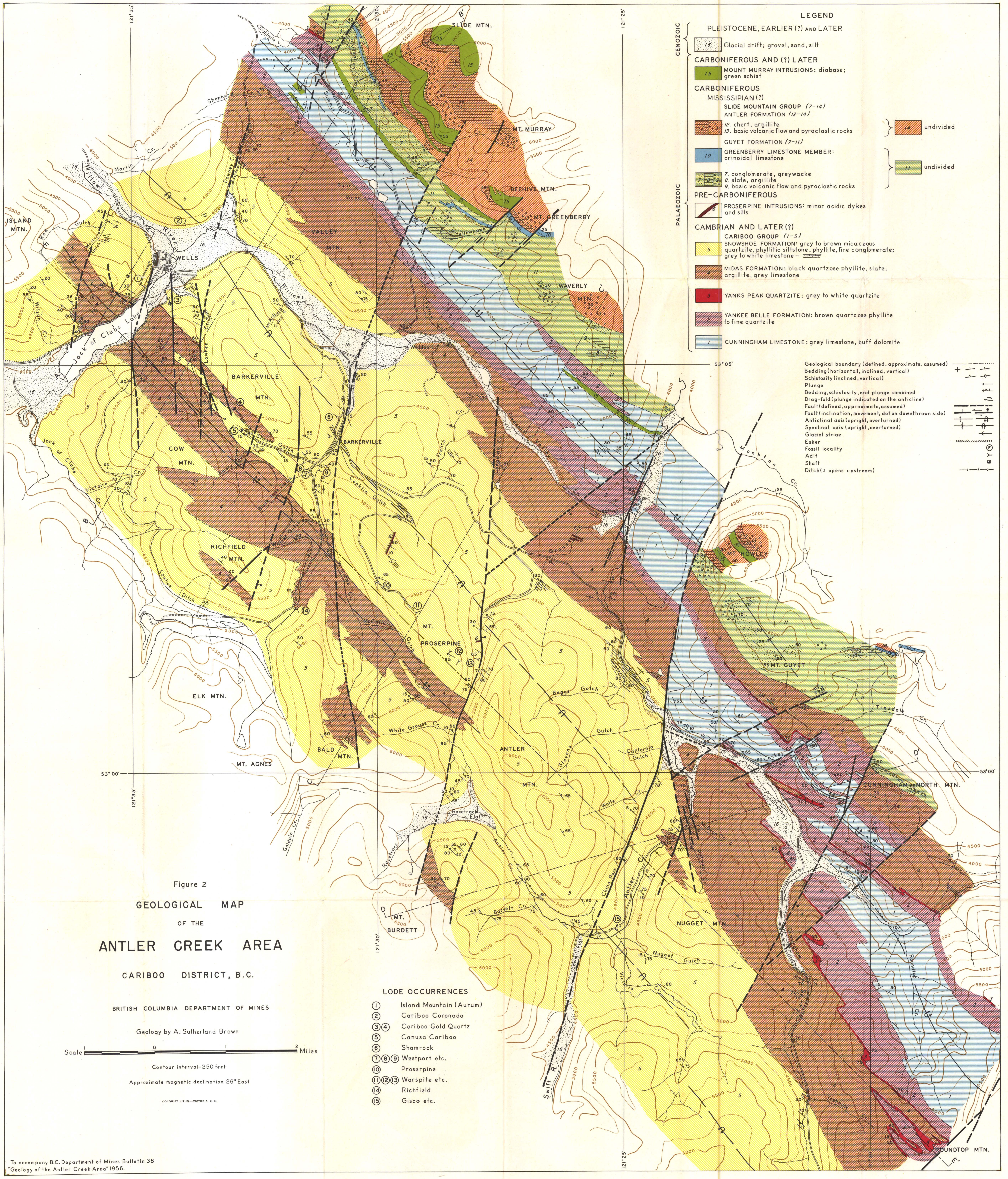
[References: Johnston and Uglow, 1926, pp. 206–207; Hanson, 1935, pp. 19–22; Benedict, 1945, pp. 755–770; *Minister of Mines, B.C.*, Ann. Rept., 1934, pp. C 22–24; 1950, pp. 102–106; Davis, N. F. G., 1937, Paper 37-15.]

Proserpine
[10]

The Proserpine group consists of sixteen Crown-granted claims and fractions in the valley of Williams Creek and the northwestern part of Mount Proserpine. The group is held by Island Mountain Mines Company Limited and was not included with the sale in 1954 of the Island Mountain property to The Cariboo Gold Quartz Company Limited. The group is bounded by the Warspite group on the southeast.

7

17364H 5.
17365H 3.
17936H Hawkeye No. 1.
18004M Midnight Fr.
18005M Vulgar Fr.
18006M Hawkeye Fr.
18007H Emory.
18008M Penn No. 1.
18069M Penn No. 2.
18658E Rex Fr.
18659E Rex No. 1.
18973M July 2nd. Fr.
18989(O) Alert Fr.
18990(O) Alert No. 1.
18991(O) Alert No. 2.
18992(O) Alert No. 3.
18993(O) Alert No. 4.
18994(O) Alert No. 5.
19050H RA No. 1.
19051H RA No. 2.
19065N October 1st.
19066N Gem No. 1.
19067N Gem No. 2.
19068N Gem No. 3 Fr.
19069N Gem No. 4.
19070N Gem No. 5.
19102P Greenberry.


LEGEND
CENOZOIC
PLEISTOCENE, EARLIER (?) AND LATER
16 Glacial drift; gravel, sand, silt
CARBONIFEROUS AND (?) LATER
15 MOUNT MURRAY INTRUSIONS: diabase; green schist
PALAEOZOIC
CARBONIFEROUS
MISSISSIPIAN (?)
SLIDE MOUNTAIN GROUP (7-14)
ANTLER FORMATION (12-14)
12. chert, argillite
13. basic volcanic flow and pyroclastic rocks
14 undivided
GUYET FORMATION (7-11)
10 GREENBERRY LIMESTONE MEMBER: crinoidal limestone
7. conglomerate, greywacke
8. slate, argillite
9. basic volcanic flow and pyroclastic rocks
11 undivided
PRE-CARBONIFEROUS
6 PROSERPINE INTRUSIONS: minor acidic dykes and sills
CAMBRIAN AND LATER (?)
CARIBOO GROUP (1-5)
5 SNOWSHOE FORMATION: grey to brown micaceous quartzite, phyllitic siltstone, phyllite, fine conglomerate; grey to white limestone
4 MIDAS FORMATION: black quartzose phyllite, slate, argillite, grey limestone
3 YANKS PEAK QUARTZITE: grey to white quartzite
2 YANKEE BELLE FORMATION: brown quartzose phyllite to fine quartzite
1 CUNNINGHAM LIMESTONE: grey limestone, buff dolomite
Geological boundary (defined, approximate, assumed)
Bedding (horizontal, inclined, vertical)
Schistosity (inclined, vertical)
Plunge
Bedding, schistosity, and plunge combined
Drag-fold (plunge indicated on the anticline)
Fault (defined, approximate, assumed)
Fault (inclination, movement, dot on downthrown side)
Anticlinal axis (upright, overturned)
Synclinal axis (upright, overturned)
Glacial striae
Esker
Fossil locality
Adit
Shaft
Ditch (> opens upstream)
Figure 2
GEOLOGICAL MAP
OF THE
ANTLER CREEK AREA
CARIBOO DISTRICT, B.C.
BRITISH COLUMBIA DEPARTMENT OF MINES
Geology by A. Sutherland Brown
Scale 1 0 1 2 Miles
Contour interval - 250 feet
Approximate magnetic declination 26° East
COLONIST LITHO. - VICTORIA, B.C.
LODE OCCURRENCES
1 Island Mountain (Aurum)
2 Cariboo Coronada
3 4 Cariboo Gold Quartz
5 Canusa Cariboo
6 Shamrock
7 8 9 Westport etc.
10 Proserpine
11 12 13 Warspite etc.
14 Richfield
15 Gisco etc.
To accompany B.C. Department of Mines Bulletin 38
"Geology of the Antler Creek Area" 1956.
SLIDE MTN.
MT. MURRAY
BEEHIVE MTN.
MT. GREENBERRY
WAVERLY MTN.
ISLAND MTN.
WELLS
VALLEY MTN.
BARKERVILLE MTN.
BARKERVILLE
COW MTN.
RICHFIELD MTN.
MT. PROSERPINE
ELK MTN.
BALD MTN.
MT. AGNES
ANTLER MTN.
MT. HOWLEY
MT. GUYET
CUNNINGHAM NORTH MTN.
MT. BURDETT
NUGGET MTN.
ROUNDTOP MTN.
Jack of Clubs Lake
Willow River
53°05'
53°00'
121°35'
121°30'
121°25'
121°20'

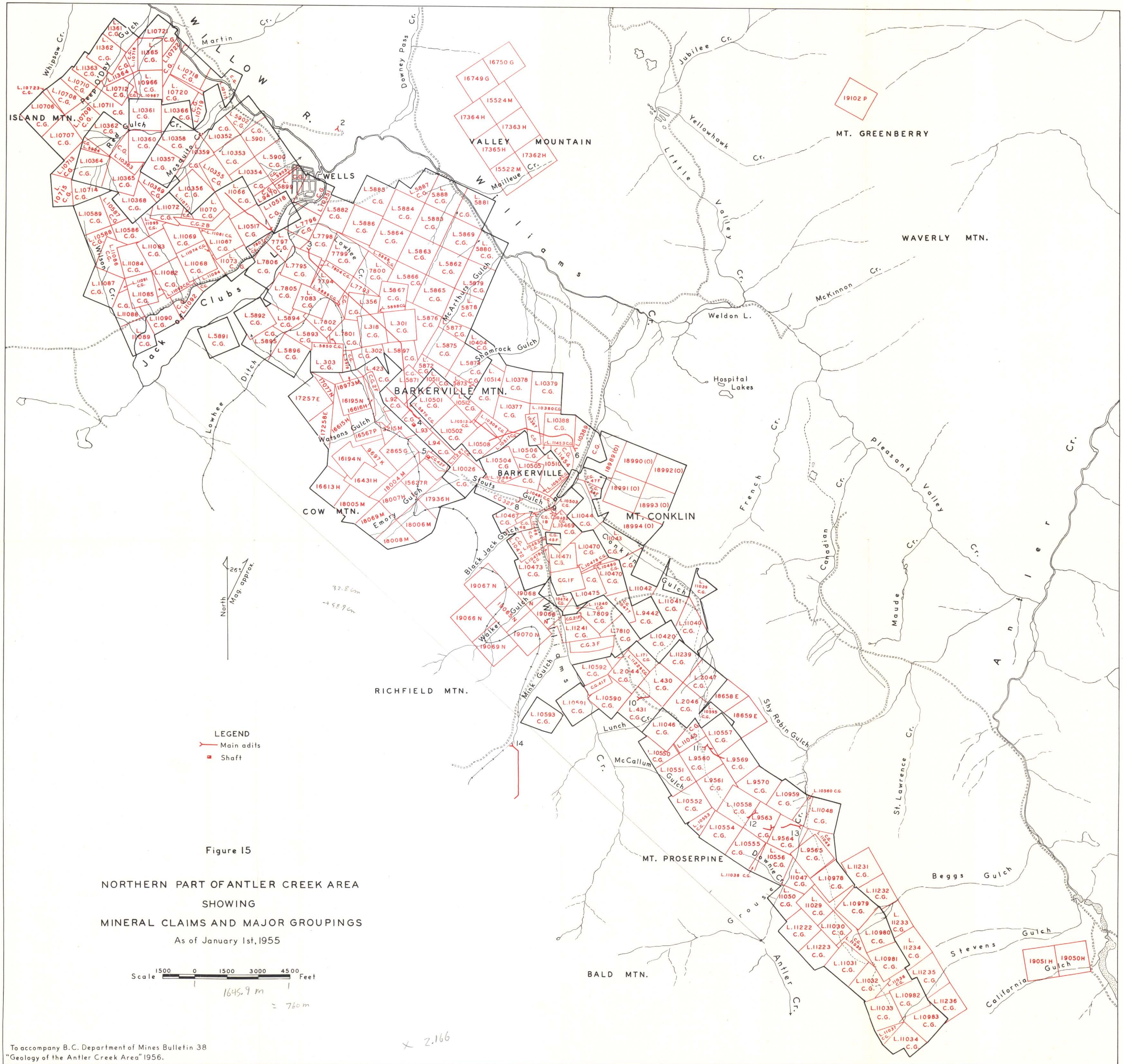
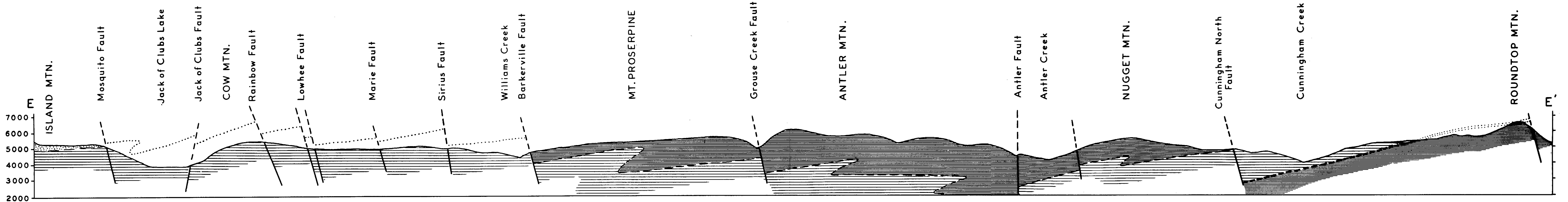


Figure 15

NORTHERN PART OF ANTLER CREEK AREA
SHOWING
MINERAL CLAIMS AND MAJOR GROUPINGS
As of January 1st, 1955

To accompany B.C. Department of Mines Bulletin 38
"Geology of the Antler Creek Area" 1956.



Glacial drift

Snowshoe formation

Midas formation

Yanks Peak quartzite

Yankee Belle formation

LONGITUDINAL SECTION E-E'

ANTLER CREEK AREA

Figure 3

Scale 1 0 1 2 Miles

To accompany B.C. Department of Mines Bulletin 38
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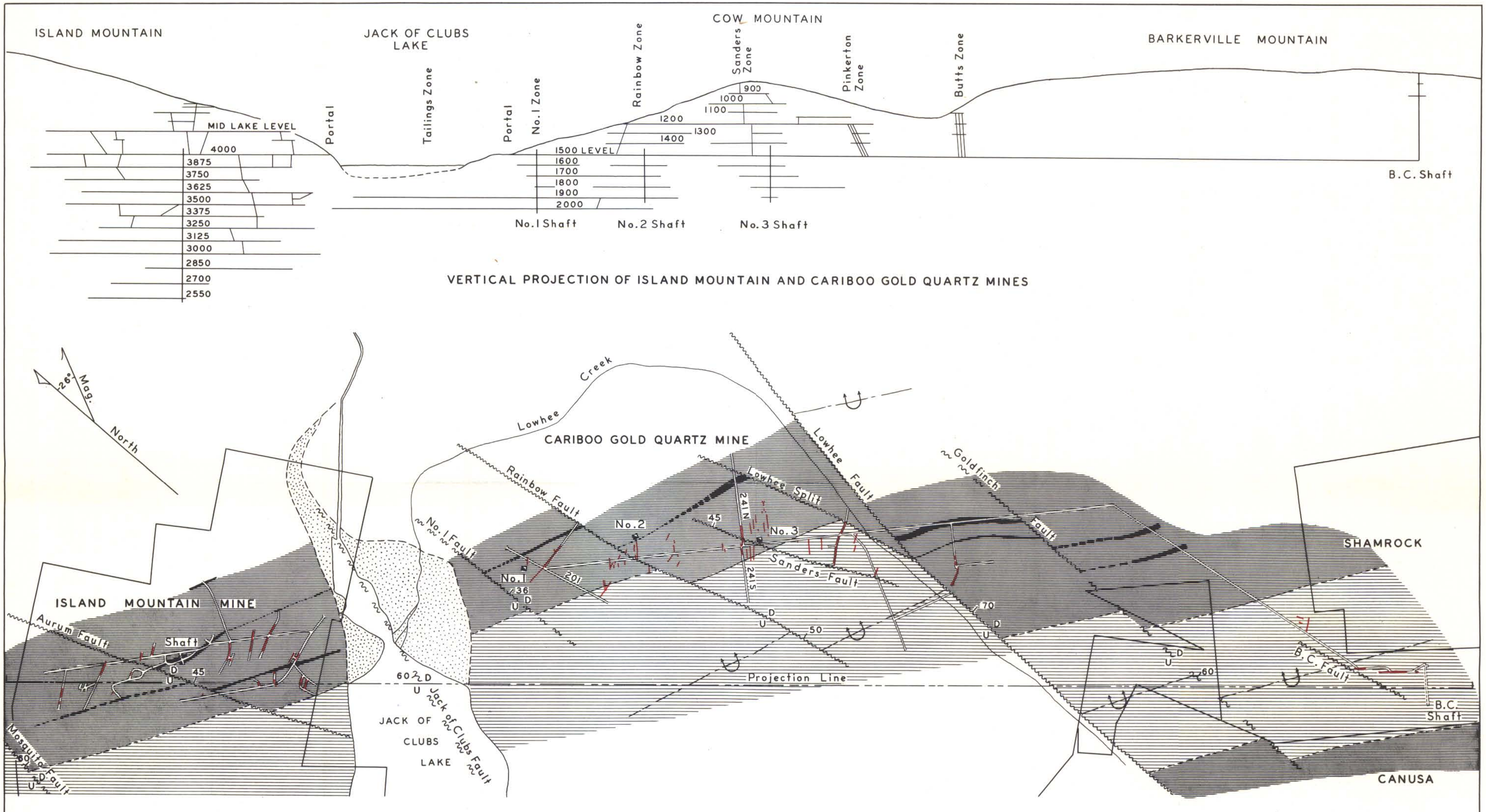

LEGEND

Recent tailings

SNOWSHOE FORMATION

Dominantly limestone

Quartzite and phyllite

MIDAS FORMATION

Figure 16

ISLAND MOUNTAIN AND CARIBOO GOLD QUARTZ MINES

Geology projected to main haulage levels (elevation approx. 4000 feet)

Scale 500 0 500 1000 1500 Feet

To accompany B.C. Department of Mines Bulletin 38
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SYMBOLS

Major veins

Fault; defined, approximate

Overturned anticlinal axis

Shaft

Property boundary