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HON. W. K. KIERNAN, *Minister* P. J. MULCAHY, *Deputy Minister*

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GEOLOGY

of the

Rocher Deboule Range

by

A. SUTHERLAND BROWN

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Geology of the Rocher Deboule Range

SUMMARY

1. The Rocher Deboule Range is in west central British Columbia and forms part of the Hazelton Mountains.

2. The range is elliptical in plan, 20 miles by 15 miles, and is isolated by wide valleys from adjacent mountain masses. The range is highly dissected with a total relief of 7,400 feet.

3. During the glacial maxima the high peaks of the range probably rose above the general level of the Cordilleran ice-sheet.

4. The Rocher Deboule Range is underlain entirely by rocks of the Hazelton group and the Rocher Deboule stock of the Bulkley intrusions, but the adjacent valley contains in addition some Tertiary rocks.

5. Only the upper two divisions of the Hazelton group occur in the map-area. They are here named the Red Rose formation and the Brian Boru formation.

6. The Red Rose formation includes 7,500 to 8,000 feet of marine and non-marine sedimentary rocks of the greywacke suite. In the map-area the formation is divided into four members as follows:—

Member	Lithology	Thickness
		Feet
D	Conglomerate, greywacke, and shale; partly marine	50–500
C	Alternating greywacke, siltstone, and shale; partly non-marine	1,000–1,200
B	Shale and siltstone; probably marine	4,000
A	Alternating greywacke, siltstone, and shale with some pebble beds and coal; non-marine	2,500+

7. The Brian Boru formation includes 5,000 to 6,000 feet of purple, green, or grey porphyritic andesite breccias and massive flows with minor hornblende porphyry andesite flows and some pyroclastic rocks.

8. The ages of these formations are not known accurately, but the Red Rose formation is probably of latest Jurassic and earliest Cretaceous age and the Brian Boru formation of early Cretaceous age.

9. The Hazelton rocks are intruded by the Rocher Deboule stock which underlies 27 square miles in the north central part of the range. The stock is formed of two phases, a slightly porphyritic granodiorite that underlies 24 square miles and a fine-grained quartz monzonite that underlies 3 square miles at the north end of the stock. The quartz monzonite appears to be the younger phase, but closely related in age and origin to the granodiorite.

10. Fortuitous exposure reveals the upper part of the stock to be elongate in shape, a composite of two domes with a connecting saddle, oriented north 25 degrees west.

11. Jointing throughout, the stock is pronounced, regular, and patterned. Three sets of joints form an orthogonal system, one set parallel to the contact, a second set striking normal to the contact and radial, and a third set dipping normal to the contact and intersecting it horizontally. The joints are believed to have resulted from cooling contraction of the stock.

12. The Rocher Deboule stock was emplaced passively after the folding of the Hazelton group, between mid-Lower Cretaceous and late Upper Cretaceous. The mode of emplacement may have been by piecemeal stoping.

13. Rocks of the Hazelton group have been thermally metamorphosed by heat from the Rocher Deboule stock and a hornfelsic aureole has been created, with increasing grade toward the stock. The most pervasive new mineral is a purply brown biotite which occurs in a zone that is 2,000 to 5,000 feet wide horizontally. Higher-grade minerals such as zoisite, amphibole, pyroxene, garnet, sillimanite, and axinite are more erratically distributed than biotite and do not form concentric high-grade zones between the biotite line and the granodiorite contact.

14. In the Bulkley Valley several hundreds of feet of poorly lithified non-marine Paleocene greywacke and shales occur that are intruded and overlain by about 200 feet of columnar andesite flows.

15. The Rocher Deboule Range is a fairly homogeneous structural unit. Folding is moderate, with bedding dips as a rule less than 45 degrees, but details of the pattern are complicated. The major fold is a large scoop-shaped syncline with diverging limbs and an axis trending about north 55 degrees east and plunging 10 to 20 degrees northeast. This fold is less noticeable than the subsidiary folds parallel to the diverging limbs.

16. Fold axes in the Hazelton and Skeena Mountains swing in a large smooth curve, from east in the southwest through northeast at Rocher Deboule, to northwest in the Skeena Mountains in the northeast. The Rocher Deboule Range represents a point of major flexure in this curve.

17. The range is cut by three large, northerly trending normal faults that raise the centre of the range as a horst.

18. The rocks of the range are dropped in relation to neighbouring mountain masses. Faults in the valleys that isolate the range may form a complete elliptical system. The youngest Hazelton rocks, the volcanic breccias and flows of the Brian Boru formation, are preserved within the range and essentially nowhere else. The fundamental structure of the range may be a volcano-tectonic depression.

19. Ores worth eight million dollars have been produced from the range, chiefly tungsten and copper ores.

20. The known mineral showings are concentrated peripherally about the stock, particularly around the northern dome of porphyritic granodiorite. They are chiefly veins filling minor shears which are extensions of joints of the orthogonal system.

21. The veins have been mineralized in three stages. The first stage is primarily pegmatitic and characterized by hornblende with scheelite and ferberite; the second stage is primarily sulphide characterized by chalcopyrite, arsenopyrite, and cobalt-nickel sulpharsenides; the third stage is characterized by milky quartz with sphalerite, tetrahedrite, galena, and chalcopyrite, forming entities which distinctly cut mineralization of the first two stages.

22. The veins probably owe their origin to the stock and their distribution to factors resulting from its cooling history, including the evolution of the joint system, minor shearing forces, and thermal control of deposition.

23. The principal producing properties are the Rocher Deboule copper mine and the Red Rose tungsten mine. These mines and the other prospects are described.

CHAPTER I.—INTRODUCTION

Mines in the Rocher Deboule Range have produced ores worth about eight million dollars. The metals produced include gold, silver, copper, tungsten, and arsenic. Other metals such as uranium, cobalt, and molybdenum are present in interesting amounts.

LOCATION AND ACCESS

The Rocher Deboule Range forms part of the Hazelton Mountains of west central British Columbia. The range extends southward from New Hazelton for about 20 miles as an isolated mountain mass surrounded by deep, wide valleys of the Bulkley, Skeena, and Kitseguecla Rivers. The range includes about 250 square miles of which the present map covers all but the small amount that is south of the 55th parallel.

The periphery of the range is readily accessible because the Prince Rupert branch of the Canadian National Railway and Highway 16 follow the Bulkley and Skeena Rivers around the eastern, northern, and western circumference. A dirt road leads up the Kitseguecla Valley for 4 miles and a trail continues to the head of the river. The interior of the range is accessible by a road up Juniper Creek to the Rocher Deboule and Red Rose mines and by trails on many of the principal creeks. Trails on Mission, Mudflat, Straw, Comeau, and Corya Creeks are in relatively good condition.

PREVIOUS WORK

The geology of the Rocher Deboule Range has been studied for more than fifty years, initially in the course of exploratory surveys and later in mineral investigations and systematic areal mapping. Geological reconnaissance along the Skeena and Bulkley Rivers was made by Dawson (1880), Leach (1909 and 1910), and McConnell (1912). Mining properties in the range were examined by Fleet Robinson (1911), Malloch (1912), Galloway (1914 and 1916), and O'Neill (1919). Kerr (1936) in a review of the mineral resources along the Canadian National Railway from Prince Rupert to Prince George discusses those of the Rocher Deboule Range.

Systematic 4 miles to 1 inch mapping was begun in the Smithers area by Lees (Armstrong, 1944a) and in the Hazelton area in 1938 by Armstrong and Gray (Armstrong, 1944b). Kindle (1940) described the mineral deposits of the Hazelton and Smithers area, revisited the active properties in 1951, and revised the memoir in 1954. Stevenson (1947) described the Red Rose and Victoria mines in detail.

FIELD WORK

The writer visited the Rocher Deboule and Red Rose mines briefly in 1951 and returned for one month in 1953, three months in 1954, and two months in 1955 to map the range and study the mineral deposits. A preliminary description of the areal geology and of the Red Rose mine was published in the Annual Report of the Minister of Mines for 1954. Field assistants Y. Kawase (1953), E. Burton (1954), W. S. Hopkins, and Y. Kamachi (1955) all gave valuable help.

PHYSIOGRAPHY

The Rocher Deboule Range is one of a number of isolated mountain masses that project northeastward from the Coast Mountains into the Interior Plateau area in north central British Columbia. Generally these mountain masses are formed of a central granitic core and a hornfelsic aureole of Hazelton rocks.

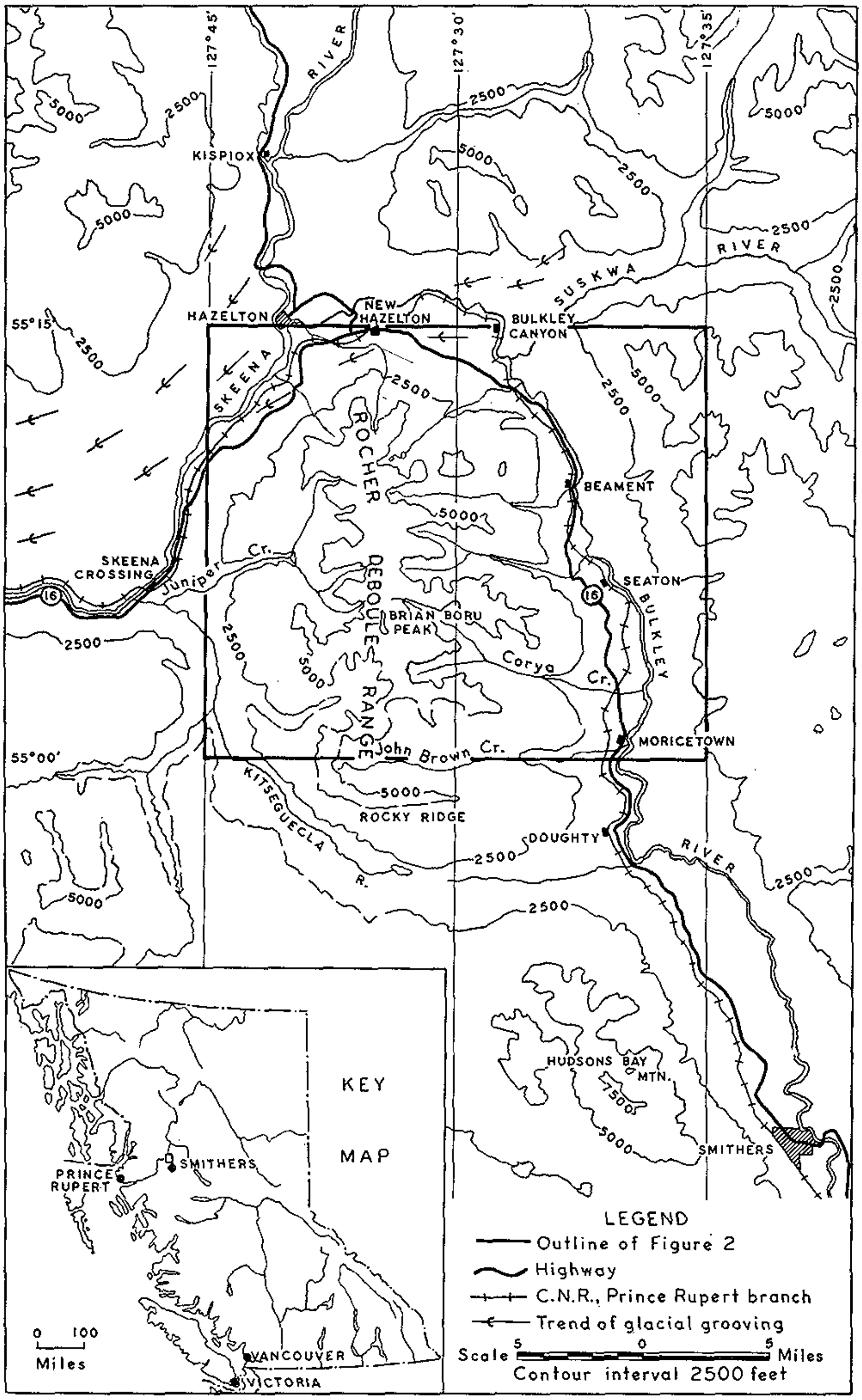

Figure 1. Index map, showing the Rocher Deboule Range and the area covered by the geological map, Figure 2.

The Rocher Deboule Range is dominated by a central north-south spine of high pyramidal peaks and connecting arêtes (*see* Plates I, II, III, and VII and Fig. 1) that extends from Hagwilget Peak (6,700 feet) at the north to Brian Boru Peak (8,200 feet). From this central spine extend lateral dissected ridges with peaks between 6,000 and 7,000 feet in elevation. South of Brian Boru Peak the central spine disappears and a major east-west ridge (Rocky Ridge) forms the southern part of the range. The valleys of the Bulkley and Skeena Rivers are about 1,000 to 1,100 feet above sea-level with the rivers incised 200 to 300 feet below the level of the main valleys. Thus the total relief is about 7,400 feet. Local relief within the range is 3,000 to 5,000 feet.

Erosion of the range has been influenced by the geology. The central spine is composed of granitic rocks or hornfelsed sedimentary or volcanic rocks. Important northerly trending normal faulting has left the central spine as a horst and has been a cause of the serration of the lateral ridges by preferential erosion along the transecting faults.

Mountains formed of volcanic, granitic, or hornfelsic rocks show characteristically different topographic details. Skylines developed in hornfelsic mountains are relatively smooth, those in granitic are finely serrate, and those in volcanic mountains are irregularly blocky. The slopes above talus aprons are steepest in volcanic mountains, intermediate in granitic, and gentlest in hornfelsic. Conversely, the talus aprons are largest in hornfelsic, intermediate in granitic, and least in volcanic mountains. The granitic mountains have a characteristic topography on the slopes, being fluted by fairly regular closely spaced avalanche chutes which are accentuated because the " interfluves " are darkened by lichen.

The drainage pattern of the range is crudely radial. The west side is drained by Juniper Creek and its tributary Brian Boru Creek, and by unnamed tributaries of the Kitseguecla River; the north side is drained by Comeau, Chicago, Mission, and Mudflat Creeks; the east side by Porphyry, Straw, Corya, and John Brown Creeks. Small dying glaciers feed many of the easterly flowing creeks. The only active glacier is the Corya glacier on Brian Boru Peak.

The Bulkley Valley and presumably the Skeena Valley are old features. Paleocene shales, sandstone, and minor conglomerate and coal, and later basic volcanic flows and dykes are found near Moricetown and Seaton station. From Doughty station to about Chink Creek the basic flows form cuestas on the valley sides and dip gently into the valley. The Paleocene rocks are not greatly disturbed, and hence it appears that the wide valley of the Bulkley existed at the close of the Cretaceous.

GLACIATION

The area owes many of its physical characteristics to sculpture by glaciers. Within the range matterhorns, arêtes, cirques, and catenary and hanging valleys are characteristic of the central part of the range (*see* Plates VII and X). Below about 5,500 feet elevation the ridges in the periphery and the passes within the range are rounded. The Bulkley and Skeena Valleys have been greatly scoured by moving ice. Projecting spurs have been faceted, and rock drumlins, drumlinoids, and grooves have been developed in the Skeena and northern part of the Bulkley Valleys. Two trends of rock drumlins and grooves meet at Hazelton and continue down the Skeena in a broad sweep.

Glacial deposits, in contrast with erosional forms, are not prominent. Within the range small moraines are related to a halt in the retreat of the present glaciers; a thin till mantles some of the gentler slopes. A few erratic boulders may be found on some of the rounded ridges. In the Bulkley and Skeena Valleys sands, gravels, and till fill the low spots and mantle the rock-cut bench of the main level of the valley.

A number of small alpine glaciers still remain on the north and east side of the central spine. All have diminished greatly in size in the recent past. The Corya glacier extends into the upper part of the main Corya Creek Valley and is the only one still active.

The evidence suggests that the high peaks of the range rose as nunataks above the Cordilleran ice-sheet even at its greatest development. Probably the range was a local centre of accumulation with snow fields sloping gently away from the middle of the range to trunk glaciers at an elevation equivalent to about the present 6,000-foot level. The ice flow that formed the rock drumlins and grooves seems to have been channelled in sweeping curves down the Skeena Valley. This flow was joined by ice that spilled over the Babine Ranges to enter the Bulkley Valley at the Suskwa River (*see* Fig. 1). Ice movement in the northerly trending part of the Bulkley Valley must have been comparatively slight.

ROCK GLACIERS

Rock glaciers are common in west- and north-facing cirques but do not occur in east-facing cirques. The largest rock glacier is that of Chicago Creek (*see* Plate V). Its upper end is not well defined, because it grades into a fairly normal if lineated talus, but it is at least 5,000 feet long, over 100 feet thick at its maximum, and extends from about 5,500 feet elevation to 4,000 feet. It occupies only half the valley width. Its sides and snout are unstable, the boulders are almost lichen free, and of the few trees established on its sides several are tilted. The whole exposed rock glacier is composed of boulders of granodiorite or volcanic rock with an average size of about 2 feet in diameter. Other rock glaciers are composed of the same materials of the same size.

Two facts about the rock glaciers of the Rocher Deboule Range deserve comment. The rock glaciers contain no hornfelsic sedimentary rock and do not occur in cirques which are formed predominantly in these rocks. A common feature of rock glaciers everywhere is the coarseness of the materials comprising them, and presumably mechanical weathering of the hornfels results in fragments too small in size to produce rock glaciers.

Rock glaciers are absent on the east-facing cirques of the range. A possible explanation of this is that until recently true valley glaciers occupied the eastern cirques whereas extensive frost riving provided the materials to the otherwise empty west-facing cirques.

LANDSLIDES

On the north face of Rocher Deboule Range extensive low angle fans are formed where creeks debouch from the mountains. These fans apparently are built chiefly by rock slides of considerable size. Similar slides have occurred recently. The size of a fan bears little relation to the drainage area of the creek, but seems to be inversely related to the stability of the head wall. A series of slides on the eastern tributary of Chicago Creek started in July of 1946 at 10 p.m. and continued until 2 a.m. The slides took place during an intense rainstorm of a generally rainy period. It is not clear whether there were continuous slides, but great noise lasted during the whole of the four hours. The material (probably mixed rock and snow) carried about 2 miles from its source at the head wall and about 1 mile beyond the point where the creek emerges from the mountains. The material was very mobile and seems to have travelled largely in the deep avalanche chute of the creek until about halfway down the fan, where it spread out and cleared a great swath through the forest. The material remaining on the site of deposition is largely of cobble and boulder size and quite well rounded. The Chicago Creek fault passes through the head wall whence the slide originated, and the granitic rocks are somewhat kaolinized along the fault.

Another fan, one where Mudflat Creek emerges from the mountains, is not built by that creek but by slides from the small creek to the east. Mudflat Creek is trenched obliquely across the fan.

A landslide of unique form is seen on upper Juniper Creek (*see* Plate I). It has clearly moved out of a depression in the arête between Armagosa and Juniper Creeks where the Chicago Creek fault crosses. Its form bears some relation to that of rock glaciers in that it has an arcuate lobate surface but in other respects it differs. For example, the slide is composed of unsorted talus, has no lineal elements, and has its maximum width at the bottom. Its width is comparable to its length. It probably formed slowly compared to other landslides, and was more a slump than a slide.

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CHAPTER II.—GENERAL GEOLOGY

The Rocher Deboule Range is underlain entirely by rocks of the Hazelton group and the Rocher Deboule stock of the Bulkley intrusions. The Bulkley Valley contains in addition to these rocks some Tertiary strata and volcanic flows and the Skeena Valley contains some granitic bosses. Much drift and alluvium mantle the valley floors.

Only the upper part of the Hazelton group has been recognized in the map-area, although lower units are reported in the southern part of the range, which was not mapped. The part of the group represented includes the upper sedimentary and the upper volcanic subdivisions, the latter so far reported only at Rocher Deboule and Hudson Bay Mountains. The Hazelton rocks are intruded by the Rocher Deboule stock composed primarily of porphyritic granodiorite. The shape of the upper part of this post-tectonic pluton is well displayed and consists of two domes connected by a lower saddle. The stock has thermally metamorphosed the Hazelton rocks, forming an aureole of outwardly decreasing intensity. Within the Bulkley Valley, strata probably of Paleocene age and overlying basic lavas occur in slightly disturbed basins.

Three parallel northerly striking normal faults divide the range into four blocks which in ensuing discussion are called the western, west central, east central, and eastern fault blocks.

Table I.—Table of Formations

Era	Period or Epoch	Unit and Thickness (Feet)	Lithology
Cenozoic.	Pleistocene and Recent.		Glacial till; glacio-fluvial sand, gravel, and silt; recent talus and alluvium.
	Unconformable contact.		
	Paleocene or later.	Moricetown lavas.	Dark aphanitic andesite lava and dykes.
	Conformable, slightly unconformable, and intrusive contacts.		
	Paleocene.	Moricetown strata.	Poorly lithified greywacke, shale, conglomerate, and coal.
Not in contact.			
Mesozoic.	Upper Cretaceous (?).	Bulkley intrusions.	Felsite dykes.
		Intrusive contact.	
		Bulkley intrusions. Rocher Deboule stock.	Fine-grained quartz-monzonite phase.
			Probable intrusive contact.
			Porphyritic granodiorite phase.
		Intrusive contact.	
		Bulkley intrusions.	Diorite dykes.
	Intrusive contact.		
	Upper Jurassic and Lower Cretaceous.	Hazelton group. Brian Boru formation 4,200′–6,000′+.	Vari-coloured porphyritic andesite flows and breccias, tuff and volcanic sandstone.
		Conformable contact (?).	
		Hazelton group. Red Rose formation 7,500′+. Member D 50′–500′.	Conglomerate, greywacke, shale, and hornfelsic equivalents.
		Interfingering contact.	
		Red Rose formation. Member C 1,000′–1,200′.	Interbedded greywacke, siltstone, and shale, and hornfelsic equivalents.
		Conformable contact (?).	
		Red Rose formation. Member B 4,000′.	Shale, siltstone, and hornfels.
		Conformable contact.	
		Red Rose formation. Member A 2,500′+.	Interbedded shale, siltstone, and greywacke with some pebble conglomerate and coal plus hornfelsic equivalents.

HAZELTON GROUP

Introduction

The Hazelton group was originally described by G. M. Dawson (1875–76, pp. 58–66) as the Porphyrite group with a type area at Tatlayoko Lake. This particular section was found by Dolmage (1924, p. 64; 1925, p. 158) to be Triassic in age, and is not now considered Hazelton although most of the remaining area of Dawson's Porphyrite group would be. Leach (1909, p. 62) thought the name Porphyrite was objectionable because it was descriptive and also thought it a misnomer if applied to the rocks about Hazelton. He renamed the rocks the Hazelton group and described as overlying them the Skeena series of non-marine shales, sandstones, and coal.

Hanson (1924a, pp. 23–27) described four divisions of the Hazelton group in the Driftwood Creek area and in the Zymoetz River area (1925, pp. 104–106); Jones (1925, pp. 122–125) at Hudson Bay Mountain amplified the description of the same divisions. These sections included a lower volcanic division, 3,000 to 4,000 feet thick, of andesitic tuffs, breccias, and flows with 500 feet of well-bedded red tuff at the top; this was conformably overlain by a lower sedimentary division consisting of 500 feet of fossiliferous well-bedded limestones, cherty shales, and sandstones; this was conformably overlain by an upper volcanic division consisting of 2,000 to 4,000 feet of andesitic to rhyolitic breccias, tuffs, and flows; and this was overlain by an upper sedimentary division of argillite, argillaceous quartzite, conglomerate, and some coal. Jones described the Skeena formation as being composed of rocks similar to the upper sedimentary division, but less metamorphosed and containing a basal conglomerate.

Armstrong (1944a, 1944b) and Kindle (1954, pp. 8–12) describe five divisions of the Hazelton group in the Smithers and Hazelton areas, including the foregoing four divisions plus an uppermost volcanic division. Armstrong discarded the name Skeena and included rocks previously termed Skeena in the upper sedimentary division of the Hazelton group from which he said they could not be separated. The following table from Kindle (1954, p. 9) summarizes Armstrong's and Kindle's views of the Hazelton group in the Smithers and Hazelton areas.

Lower Cretaceous or later.	Hazelton group.	Volcanic division 3,000.	Andesitic, dacitic, rhyolitic, and basaltic lavas, tuffs, and breccias; minor sandstone and shale.
Upper Jurassic and Lower Cretaceous.		Sedimentary division 5,000.	Sandstone, shale, argillite, slate, quartzite, conglomerate, greywacke, tuff, arkose, hornfels, coal.
Middle or Upper Jurassic.		Volcanic division 4,000.	Andesitic, dacitic, rhyolitic, and basaltic lavas, tuffs, and breccias.
Early Middle Jurassic.		Sedimentary division 500.	Argillite, quartzite, limestone.
Early Middle Jurassic or earlier.		Volcanic division 4,000.	Andesitic, dacitic, rhyolitic, and basaltic lavas, tuffs, and breccias; minor limestone.

The Hazelton group can be defined as a thick group of volcanic and marine and non-marine sedimentary rocks largely of Middle and Upper Jurassic age but including some lowermost Cretaceous rocks. The volcanic rocks are predominantly intermediate in composition and variably coloured; characteristically they are porphyritic andesite flow breccias. The sedimentary rocks are in large measure of volcanic derivation and many belong to the greywacke suite. Argillaceous rocks predominate, but sandy and conglomeratic rocks are common; coal and carbonaceous sediments occur in the upper part of the group.

The Hazelton group underlies about 60 per cent of the mapped part of the Rocher Deboule Range or about 130 square miles. Only the upper two divisions are recognized, although Armstrong has mapped the middle volcanic division in the southern part of the range (*Geol. Surv., Canada,* Map 44-23). It is possible that in the western fault block rocks mapped as belonging to the upper two divisions may be older. In this report the upper sedimentary division is named the Red Rose formation from a type section south of Red Rose Creek and the upper volcanic division the Brian Boru formation after a type section in the vicinity of Brian Boru Peak.

Red Rose Formation

The Red Rose formation underlies about 12 per cent of the area mapped, chiefly in the north central part of the range on either side of the Rocher Deboule stock. It also probably underlies much of the area of covered benches north of the range. The formation is named for the good section exposed south of Red Rose Creek (*see* Fig. 6, Section C-C′). Neither here nor elsewhere in the map-area was the base of the formation seen, but the section on Red Rose Creek includes 7,500 to 8,000 feet of sedimentary rocks, and hence probably exposes most of the unit (compare thickness of the division in Kindle's table). The Red Rose formation is overlain by the volcanic rocks of the Brian Boru formation without obvious unconformity.

The Red Rose formation is composed entirely of sedimentary rocks of the greywacke suite.* Much of the detritus composing the rocks is derived ultimately from a volcanic source. In general, Red Rose rocks are well-bedded dark grey rocks of similar composition though variable grain size. Most of the formation is argillaceous but much is arenaceous and some is conglomeratic. A large percentage of the formation is within the metamorphic aureole of the Rocher Deboule stock and hence the rocks are indurated and those near the stock are hornfelsic. Beyond the aureole the rocks are softer and in some cases poorly consolidated.

Volcanic rocks occurring within the formation in minor amounts have been interpreted as flow rocks, but crosscutting relationships may be found for all the major bodies in the vicinity of Red Rose Creek. Although the Red Rose formation locally does not appear to contain any volcanic flows, some fragmental material may be pyroclastic in origin and a majority of detritus appears to be ultimately of volcanic derivation. In the greywackes and conglomerates a majority of rock fragments are volcanic porphyries and the abundant detrital feldspar grains are also probably derived from porphyries.

The Red Rose formation has four subdivisions which are recognizable in much of the area. These are listed in the following table.

Member	Lithology	Thickness
		Feet
D	Pebbles and cobble conglomerate, greywacke, shale	50–500
C	Interbedded greywacke, siltstone, and shale	1,000–1,200
B	Shale and siltstone	4,000
A	Interbedded shale, siltstone, and greywacke with some pebble beds and coal	2,500+

* Pettijohn (1949, p. 244) defined greywacke as "a distinct type of sandstone . . . composed of large, very angular detrital grains, mainly quartz, feldspar, and rock fragments. . . . These grains are set in a prominent-to-predominant 'clay' matrix which was, on low-grade metamorphism, converted to a mixture of chlorite and sericite and partially replaced by carbonate." Rocks of similar nature, of grain size ranging from that of conglomerate to that of silt, and associated grey and black shale are included in the greywacke suite.

No obvious angular unconformities were observed between these units, but the presence of disconformities or minor unconformities seems likely. Indeed, the sequence building up to coarse conglomerate at the top of the Red Rose formation probably indicates unconformities nearby if not within the map-area.

Because the members are composed essentially of similar rocks in different proportions it is difficult to distinguish with certainty at isolated outcrops or structurally complex localities which member is seen. It may even be difficult to distinguish between members A and C where considerable sections are exposed. Consequently, members A and C are shown in one colour in Figure 2, and where it is obvious on the ground which member outcrops it is also obvious on the map. Furthermore, one member passes into another by gradual transition and the mapped contacts between members are actually zones of variable width.

Member A

Member A is composed of interbedded greywacke and shale in subequal amounts with siltstone and some thin pebble beds and impure coal. The greywackes may be carbonaceous, and not rarely contain altered wood fragments and leaf impressions. These rocks are commonly very feldspathic and might in some instances be called arkose, but most commonly they are more accurately described as greywacke. Most of the shales are carbonaceous and some are highly so. Thin beds of impure coal are not rare. In general the member appears to be of non-marine origin. Bedding is well marked because of repeated variation in rock type. Beds range from a few inches to about 10 feet thick and most are 1 foot to 3 feet thick. Minor laminations are ubiquitous, but not readily apparent. The greywacke has been changed little by thermal metamorphism, but the shales and siltstones have been greatly hardened.

About 2,500 feet of member A is exposed south of Red Rose Creek in a section complicated by a complex anticlinal crest. Transition to member B occurs through about a 500-foot stratigraphic thickness in which greywacke and pebble beds become rare. The member is also exposed across a fault on the north side of the creek and along the northeastern flank of the Rocher Deboule stock. The rocks exposed south of New Hazelton and along the Bulkley Canyon at the north edge of the map-area probably belong to this member.

Microscopically, the unmetamorphosed greywackes are composed dominantly of plagioclase, orthoclase, rock fragments, and quartz with minor iron ores and carbonaceous and micaceous material. Feldspar, variably altered, forms 50 to 70 per cent of the rock except in the case of some coarse greywackes in which rock fragments are dominant. Rock fragments, mostly porphyry, but including some siltstone or chert, commonly form 10 to 20 per cent but may form as much as 70 per cent of some coarse greywackes. Quartz rarely forms as much as 20 per cent. Some specimens contain 5 to 10 per cent of grains of unknown origin now composed entirely of chlorite. Sand-sized particles are angular to subangular. Matrix forms a variable amount of the whole and commonly is recrystallized to chlorite. Thermal metamorphism is locally intense and pyroxene, amphibole, garnet, zoisite, and biotite may be produced (*see* Metamorphism, p. 35).

Member B

Member B is composed entirely of shale and siltstone and their thermally metamorphosed equivalents. The unmetamorphosed rock is a dark grey to black, not prominently bedded shale, silty shale, or rarely a very fine siltstone. Many of these rocks are significantly carbonaceous. Thermal metamorphism transforms the rocks readily to rusty weathering yellowish-grey argillite or hornfels or in some cases to a dark spotted hornfels. As a result of even slight metamorphism the bedding is largely destroyed and the rocks break down on mechanical weathering to small prismatic fragments. No coal, woody matter, or leaf impressions were found. On the ridge north of Red Rose Creek one thin local carbonate bed is full of obscure tubular structures, probably of marine algal origin. Evidence of the member's origin is more suggestive of marine than non-marine deposition considering the thick uniform section of grey to black shales, the lack of wood or leaves, and the carbonate bed.

The section south of Red Rose Creek exposes about 4,000 feet of member B. Transition from member A occurs through a 500-foot stratigraphic thickness, but the transition to member C is more abrupt. The member as a whole is monotonous in character but in many places contains variations in the form of sills and dykes chiefly of purplish andesitic porphyry. The member also occurs north of Red Rose Creek and on the lower slopes of the ridges at the head of Mudflat and Porphyry Creeks.

Microscopically, the unmetamorphosed rocks are semi-opaque masses of very finely divided carbonaceous matter, clay, and detrital minerals. Commonly there are some silt-sized quartz grains and muscovite shreds, and thin shreds of concentrated opaque carbonaceous matter. Some laminæ are composed dominantly of fine silt or particles about 0.01 millimetre in diameter. Most rocks are thermally metamorphosed in some degree with growth of cordierite spots in some, chlorite, muscovite, or biotite in others, and with relatively large pyrite porphyroblasts common in all. In general the metamorphosed rocks are much less opaque than the unmetamorphosed ones (*see* Metamorphism, p. 34).

Member C

Member C is composed of interbedded greywacke, arkosic greywacke, siltstone, and carbonaceous shale in varying but sub-equal amounts. Most of the greywackes and siltstones are a middle grey, whether fresh or weathered, but some weather a chocolate colour. Some of the greywackes are slightly calcareous. Most of the shales are dark grey and carbonaceous. Bedding is pronounced as a result of repeated variations in rock type. Some beds may be as thick as 30 feet, but most are about 2 to 5 feet thick. Most of the siltstones and shales are finely and obscurely laminated and may be interlaminated. A few beds show wave ripple marks. Fossils are rare and consist only of wood or leaf fragments and worm tubes. Evidence is too scanty to say whether the member is of marine or non-marine origin.

Member C is in most ways similar to member A, but has no pebble beds, no coal, and fewer plant fossils; it does have some wave ripple-marked beds and may have a slightly different average mineral composition. There is an over-all coarsening of arenaceous beds and decrease in amount of argillaceous beds toward the top of the member. Hence member C could be regarded as a transition between members B and D. Metamorphism has had the same general effect on member C as on member A.

Member C forms about 1,200 feet of the section south of Red Rose Creek. The member is also exposed at the very top of Red Rose Peak, the tops of ridges at the source of Mudflat and Porphyry Creeks, and less well in the timbered lower slopes and ridges in the western part of the range.

Microscopically, the unmetamorphosed arenaceous rocks and siltstones of this member are composed chiefly of feldspar, quartz, and rock fragments with lesser amounts of detrital muscovite flakes, opaque minerals, matrix, and some grains of indeterminate origin now composed mostly of chlorite. Feldspars form about 40 per cent of most rock, quartz about 25 per cent, and rock fragments about 20 per cent. Plagioclase generally exceeds orthoclase although both are normally present. Orthoclase is almost completely altered to fine felted sericite and plagioclase may be so altered even in unmetamorphosed specimens. Some quartz is strained and recrystallized. Rock fragments include microporphyry, chert, and siltstone. The former commonly has a moderate amount of opaque matter in it. In partly metamorphosed rocks it is difficult to tell whether some micaceous or chloritic grains are altered feldspar grains or rock fragments. Opaque material including pyrite, iron oxides, and carbonaceous matter is more common in the coarser specimens than in the fine. Matrix constitutes a small but variable amount that probably does not exceed 5 to 10 per cent in the greywackes but is considerably greater in some siltstones and silty shales. Sand-sized grains are mostly quite angular, but some are subangular and some rounded. Sorting is relatively good in many specimens. In summary, the arenaceous rocks have the general mineral composition and some of the textural attributes of high rank or feldspathic greywackes, but they show better sorting and less matrix than is common. Nonetheless they belong to the greywacke suite and are better called greywackes than arkoses and possibly formed as a result of winnowing action on more normal greywackes. The siltstones and silty shales are true feldspathic greywacke siltstones.

The argillaceous rocks of this member are essentially similar to those of members A and B; chiefly carbonaceous shales and silty shales. The silty shales have as much as 50 per cent of detrital quartz and feldspar, the former always the larger percentage in contrast to the greywackes. Carbonaceous matter and opaque minerals form an important part of the silty shales and fine micaceous or clay matrix the remainder. The shales differ from the silty shales only in the absence of silt. The effects of thermal metamorphism in member C are similar to those in members A and B.

Member D

Member D is composed of conglomerate, greywacke, tuffaceous greywacke, and some siltstone or shale. Conglomerate is the characteristic although not everywhere the predominant rock. The unmetamorphosed conglomerate is a middle grey rock which, except on fresh surfaces, is not apparently very different from the greywackes of the formation. At its coarsest (*see* Plate VIII) it is composed of cobbles consisting chiefly of andesitic porphyry, but including some chert and greywacke, and with a matrix similar to the greywackes throughout the Red Rose formation. Typically it is pebble conglomerate in which pebbles of chert may outnumber those of porphyry, siltstone, or greywacke in a greywacke matrix. Quartz cobbles or pebbles are rare. Sphericity of the cobbles or pebbles is low, although the rounding is fair to good (*see* Plate VIII). The matrix is identical with the greywacke described in member C except that the chert grains may be slightly more numerous. The greywacke beds are likewise similar to those of member C except that rarely they are composed of a much higher percentage of porphyry fragments (60 per cent) and seem to be truly tuffaceous. On Tiltusha Peak 50 feet of volcanic rock occurs near the top of the conglomerate. It is not certain whether this rock is a sill or perhaps a flow that is the precursor of the Brian Boru formation.

Bedding is not in general as pronounced as in members A and C. Cut and fill structures are common in mixed greywacke and pebble beds. Marine fossils have been found in float identical with the topmost tuffaceous beds of this member or the lowest tuffaceous beds of the Brian Boru formation.

Member D is of variable thickness. It is up to about 450 feet thick on the peak between branches of Brian Boru Creek, and is about the same across the Chicago Creek fault at the north end of the mass rising to Brian Boru Peak. On Tiltusha Peak there is about 375 feet of conglomerate including about 50 feet of volcanic rocks. On the ridge south of the head of Porphyry Creek there is only a few tens of feet of conglomerate. In the western fault block member D may be 500 feet thick. The section on Tiltusha Peak is almost entirely conglomerate, much of it of cobble size. In the sections at the head of Brian Boru Creek the member is dominantly greywacke with 20 to 30 per cent of pebble beds scattered fairly regularly through it and about 30 per cent of siltstone and black argillite. Member D is overlain by andesitic volcanic rocks of the Brian Boru formation without observable angular unconformity.

Brian Boru Formation

The Brian Boru formation underlies about 45 per cent of the map-area, forming all of the eastern fault block, most of the western, and part of the central fault blocks. The formation is named for the good exposure on Brian Boru Peak. It is 5,000 to 6,000 feet thick and the top has not been observed. The formation is composed of porphyritic andesite flows and breccias with minor amounts of tuffs. No subdivision into natural units can be made on the basis of present knowledge.

The Brian Boru formation includes 4,200 feet of flows and minor tuffs in the type locality on Brian Boru Peak. The base is formed of about 100 feet of tuffs that resemble flow rocks. Above the tuffaceous porphyritic andesite both massive flows and breccias predominate. On the ridges between Straw and Porphyry Creeks about 5,000 feet of volcanic rocks occur between the Pangea fault and the top of the exposed section (*see* Fig. 6). Breccias and some tuffs are well developed in the upper part of this section. On the ridges on either side of lower Juniper Creek in the western fault block, about 5,000 to 6,000 feet of breccia, flow rocks, and some tuffs lie above Red Rose formation. Exposures of 3,000 to 4,000 feet of the formation are common in other localities. Hence the formation is not less than 4,200 feet thick and, unless there is duplication by unknown faults, it must be about 6,000 feet thick.

The dominant and characteristic rock of the Brian Boru formation is a porphyritic andesite, in which feldspar phenocrysts with an average length of about 3 millimetres form from 20 to 40 per cent of the rock. The andesite occurs as massive flows or breccia and may be various shades of purple, green, or grey. All varieties tend to weather darkish brown and, regardless of texture or colour, all have the same general appearance. Single flows are of the order of 100 feet thick and are generally homogeneous throughout. Individual flows are more readily distinguished at a distance than close, and structural attitudes are best judged from afar. Many units are seen in places to be composed of breccia on large fresh surfaces. Breccia is believed to be very common but, as fragments and matrix are identical and the whole well bonded, the texture does not show as a rule on either weathered or fresh surfaces. Where this texture can be seen, fragments generally range from 3 inches to a foot in diameter and are mostly subangular.

A small percentage of the formation is a dark greenish-grey hornblende porphyry andesite. This rock occurs as dykes within the formation, but is believed to form flows in the upper part of the formation. Outcrops of such rock are most common along the eastern slopes of the range. Rocks intermediate between the hornblende porphyry and the normal andesite also occur in which the feldspar phenocrysts form only about 15 per cent of the rock.

Volcanic rocks forming the Brian Boru formation have not been obviously changed by thermal metamorphism. Even adjacent to the Rocher Deboule stock, rocks that microscopically are quite changed show macroscopically little indication of this fact except a pervading purplish-brown colour that results from growth of biotite.

Tuffs and volcanic sedimentary rocks form only a small part of the formation. These rocks may be composed essentially of grains and fragments such as could be derived from fragmentation or erosion of the porphyritic andesites, and some of them are difficult to distinguish from the flows. This type of tuff appears to be most common near the base of the formation. Other tuffaceous rocks, quite different in appearance from the andesites, may be composed of an assortment of angular fragments, many of which are altered to clay minerals. Commonly these latter rocks are quite mottled, being grey-green with many brown fragments. Some are poorly bedded and poorly sorted; others are well bedded and well sorted. The first appear to be of pyroclastic origin whereas the latter are of mixed sedimentary and pyroclastic origin.

The thickest section of tuffs and volcanic sedimentary rocks observed is along the Canadian National Railway track north of Beament station. It is possible that these are member D of the Red Rose formation. Here a section 450 feet thick of these rocks is overlain by normal green porphyritic andesite and is cut by similar feeder dykes. Considerable variation occurs within the section, which includes bedded tuffs, poorly sorted angular breccias, and water-lain conglomerates. Boulders and fragments of porphyry, chert, and white rhyolite are common. A few coaly beds occur, and adjacent to some of the dykes carbonaceous material has been distilled so that it cuts across stratification near the dykes and occupies vesicles within them. The rocks of this section resemble to some degree those of member D of the Red Rose formation. If a large normal fault in the Bulkley Valley passes to the west of this section, as it seems to do, then these rocks may belong to the Red Rose formation.

The porphyritic andesites that comprise all but a small part of the Brian Boru formation are mostly similar microscopically. Phenocrysts of fresh labradorite, or less commonly andesine, form 20 to 40 per cent of the rock and have an average length of 2 to 3 millimetres. These may have 4 to 5 oscillatory zones with only 5 to 10 per cent variation in anorthite content. Mafic phenocrysts form at most 10 per cent and commonly about 5 per cent of the rock. Hornblende, augite, or biotite may be present as phenocrysts although the latter generally is an alteration product. Most rocks contain both hornblende and augite; the hornblende forms the larger grains and is commonly altered, whereas the augite is generally fresh. The hornblende is commonly slightly resorbed and may have a rim of iron oxides which in the purplish andesites may replace much of the hornblende. Other alteration products of the hornblende include biotite, chlorite, and in some cases epidote. Augite, though generally fresh, may be altered to chlorite and calcite. The matrix of the porphyritic andesites consists predominantly of small plagioclase laths and includes chlorite, augite, and iron ores; it may contain some small ophitic grains of orthoclase, calcite, and epidote. The texture of the matrix is commonly felted, but may be trachytic.

Hornblende porphyries are also andesites. They contain rare plagioclase phenocrysts and a few phenocrysts of augite, whereas hornblende phenocrysts form 15 to 20 per cent of the rock. The latter phenocrysts have an average size 1 to 2 millimetres long by 0.2 to 0.4 millimetre in section. The hornblende commonly has a thick rim replaced by iron ores. The matrix is formed of trachytic plagioclase laths with augite, chlorite, and iron ores. The hornblende porphyries resemble normal porphyritic andesites from which the feldspars have been removed and the remainder slightly enriched in hornblende crystals.

Some of the tuffaceous rocks are composed essentially of plagioclase grains and porphyry fragments with a fine matrix of chlorite and clay minerals. Others are composed of angular grains now composed of felted or massive clay minerals, but presumably originally feldspar or porphyry, some partly altered plagioclase, and about 30 to 40 per cent very fine cherty matrix. Some of the latter tuffs contain some quartz grains and rarely fragments of flow-banded acidic volcanic rocks.

Age and Correlation

The Hazelton group as a whole ranges in age from Middle Jurassic to early Lower Cretaceous. The ages given by Kindle (1954) for the upper two divisions of the group are Upper Jurassic and Lower Cretaceous, and Lower Cretaceous or later, respectively.

The basis of the assigned age of the upper sedimentary division is stated by Kindle (1954, p. 12):—

"Fossil fauna and flora of Upper Jurassic or Lower Cretaceous age were collected by Armstrong (Armstrong and Kindle, 1953) from many places in the Hazelton district. The flora were generally divisible into collections correlated provisionally with either the Kootenay or Lower Blairmore of Alberta, of Lower Cretaceous age. The marine shell collections, on the other hand, were generally identifiable as of either Upper Jurassic or Lower Cretaceous age."

Of the uppermost volcanic division Kindle (1954, p. 12) states: "Because of their stratigraphic position at the top of the Hazelton group, they must be of Lower Cretaceous or later age."

Recently Bell (1956) has considered the age of flora of the Hazelton group. He states (pp. 22, 23) that out of forty-four localities in the Hazelton map area:—

"An early Cretaceous, Neocomian-Barremian age equivalent (Kootenay) is assigned with some confidence to florules from 13 localities. . . . A probable Aptian age, equivalent to that of the lower flora of the Blairmore group in Alberta or to the flora of the non-marine Bullhead group in British Columbia, is assigned to florules from 6 localities. . . . Plants from the remaining 23 localities in the Hazelton area are too few in number for reliable judgment of age or contain either new species or species that occur in both Neocomian-Barremian and Aptian floras of Alberta. Their assignment even to an early Cretaceous age cannot be made with assurance. They are, however, considered to be of early Lower Cretaceous age rather than Jurassic . . . (but) a possibility of a Jurassic age cannot be wholly dismissed."

The only one of these localities in the Rocher Deboule map-area is number 2401, which is on the Bulkley River below Moricetown. From this locality a Neocomian-Barremian flora was collected. The rocks are presumably member A of the Red Rose formation. Other definite Neocomian-Barremian localities are found in the Bulkley Canyon just north of the map-area in rocks probably of member A.

Fossils collected by the writer do not permit the assignment of a precise age for the local units of the group. From the Red Rose formation the following plants were collected and identified by W. L. Fry, formerly of the Geological Survey of Canada: G.S.C. Plant Locality No. 4983: Western end of ridge south of Red Rose Creek, member A.

cf. *Thrysopteris* sp.

G.S.C. Plant Locality No. 4984: Half a mile south of New Hazelton, probably member A.

Cladophebis fisheri Knowlton.
Cladophebis virginianses.
Coniopteris sp.
Podozamites lanceolatus L & H.
Czekanowskia sp.
Ginzoites pluripartita (Schimper).

G.S.C. Plant Locality No. 4985: Two miles west of Brian Boru Peak, member C.
Pterophyllum sp.
Podozamites sp.

Dr. Fry commented as follows: "The age of the Hazelton sediments still remains inconclusive because of the lack of extensive stratigraphically collected specimens. Earlier collections made by the Geological Survey were identified by W. A. Bell. He suggested correlation with the Lower Cretaceous Kootenay. In other instances he remarked that either an Upper Jurassic or Lower Cretaceous age was possible. This collection falls into the latter category."

The only fossils collected from the Brian Boru formation are pelecypods and belmnites of no diagnostic value according to H. Frebold of the Geological Survey. They were found in a large block of talus in the cirque at the head of the north branch of Brian Boru Creek, and may represent either tuffaceous rock at the base of the Brian Boru formation or similar rock in the uppermost part of member D of the Red Rose formation.

The Hazelton group within the map-area seems to have been deposited under alternating marine and non-marine conditions. Member A of the Red Rose formation is of non-marine origin, B is possibly marine, C in part at least is non-marine, D and the lower part of the Brian Boru formation are in part at least marine.

Regional evidence shows a general progression within the Hazelton group from marine conditions toward non-marine. The evidence within the map-area does not essentially conflict with this general progression.

Armstrong (1944a and b) discarded the Skeena formation because:—

"Coal is found associated with continental strata throughout the Hazelton group. . . . These continental, coal-bearing members of the Hazelton group have hitherto been thought to comprise the Skeena formation or series and to overlie the Hazelton group conformably, according to some geologists, or unconformably according to others. Recent studies in this and the adjacent Smithers map-area have, however, indicated that no satisfactory stratigraphic division can be made and that continental strata comparable with the Skeena appear at various horizons in the Hazelton group."

Armstrong's rejection of the Skeena formation appears sound. It is evident that Leach (1909, pp. 62–64; 1910, p. 94) included in the Skeena formation the small basins of Paleocene sedimentary rocks that he considered to be synclines and identified with synclines of "Skeena" rocks such as those of the Telkwa coalfields. Hence Leach's concept that the Skeena formation overlies the Hazelton group conformably. The evidence of the map-area adds weight to Armstrong's rejection because marine rocks occur in an upper part of the group that would have been considered the Skeena formation.

DYKES OLDER THAN THE PORPHYRITIC GRANODIORITE

Dykes and sills that were intruded prior to the emplacement of the Rocher Deboule porphyritic granodiorite are of two sorts. They include porphyritic andesites related in composition, texture, and origin to the Brian Boru formation and fine diorites that probably were precursors of the stock.

Porphyritic andesite dykes and sills are essentially identical with the main flow rocks of the Brian Boru formation. Their colour varies from purple to greenish-grey and their phenocryst content from 20 to 40 per cent. As do the flows, a small percentage of the dykes contain more hornblende phenocrysts than feldspar. Probably the only notable difference is that the dykes and sills are commonly vesicular or amygdaloidal whereas the flows are not. Vesicles may be partly or wholly filled with fibrous amphibole and contain traces of pyrite or rarely chalcopyrite. A few dykes of similar composition are younger than the granodiorite. These younger andesite dykes commonly contain about half as many feldspar phenocrysts as the older ones, but are still difficult to distinguish in all cases.

The porphyritic andesite bodies are commonly 30 feet thick or less, but one in the western fault block is very much thicker. The sills may be quite complex in shape, though generally conforming with the bedding of the older rocks. In a section of uniformly gently dipping argillites, sills have been seen that are dish shaped, crescentic, or combined into root-like or laterally forked masses. Good examples of such sills may be seen on the ridge north of the Red Rose mill. Near Beament station (*see* p. 23) and in a few other localities there appears to be a feeder relationship between large dykes and overlying flows. Possibly many of the dykes were feeders for the Brian Boru flows.

A large body of porphyritic andesite that forms a cuesta south of lower Juniper Creek *in the western flank of the range is judged by details of its contact to be a sill.* This body may be 300 to 500 feet thick, and hence much larger than other sills in the centre of the range. Nevertheless, it is macroscopically almost identical with them. Microscopically, it differs in that biotite is the only original mafic phenocryst, and the matrix is more coarsely crystalline so that plagioclase, quartz, and orthoclase can all be distinguished. This sill is composed of:—

	Per Cent
Andesine phenocrysts	40
Biotite phenocrysts	5
Quartz phenocrysts	1
Calcite	10
Fine plagioclase, quartz, orthoclase	35
Chlorite	5
Pyrite	2
Apatite	1

Diorite bodies are all concentrated about the upper end of Red Rose Creek where three large and several small dykes intrude the Red Rose formation, cut the porphyritic andesite dykes related to the Brian Boru formation, and are in turn cut by the porphyritic granodiorite. These dykes include the " mine diorite " of the Red Rose mine, which is known from drilling to be tongue shaped (*see* p. 56). The large dykes are about 400 feet wide and the central one can be traced for more than a mile, although the central section is cut out by the granodiorite on upper Red Rose Creek (*see* Fig. 2).

The diorite is a fine-grained, dark greenish-grey rock. Microscopically, it has a granitoid texture but with some noticeably larger than normal euhedral plagioclase crystals. It is composed of 65 per cent zoned plagioclase crystals (An_{42-26}) and 30 per cent pale green hornblende, now mostly a patchy mosaic of amphibole and biotite. Accessory minerals include quartz, iron ores, and sphene. The average size of plagioclase laths is 1.2 by 1.2 by 0.4 millimetre and of hornblende crystals 0.8 millimetre in diameter.

THE ROCHER DEBOULE STOCK

The Rocher Deboule stock underlies about 27 square miles in the northern two-thirds of the central fault blocks. With the exception of one or possibly two small bosses in the Skeena Valley and the diorite dykes of Red Rose Creek, the Rocher Deboule stock is the only plutonic body in the map-area. Another body underlies the low hills at the south end of the range (Armstrong, 1944a).

Most of the Rocher Deboule stock is well exposed in the central peaks and ridges of the range. In this area the only cover is that formed by felsenmeer, talus, and small glaciers. However, the southern end of the stock is covered by the large Corya moraine and the northern end is largely mantled by valley glacial and alluvial deposits. The stock is exposed over a vertical distance of 6,500 feet.

The Rocher Deboule stock is composed essentially of two rocks, slightly porphyritic granodiorite* and fine-grained quartz monzonite (*see* mineral composition of Table II). The porphyritic granodiorite underlies about 24 square miles and forms the main mass of the stock, whereas the quartz monzonite underlies only about 3 square miles. The porphyritic granodiorite is homogeneous, whereas the quartz monzonite is slightly variable. Neither rock is foliated. The quartz monzonite appears to be younger than the granodiorite, but probably is closely related in age and origin.

Porphyritic Granodiorite

The dominant type is a light grey mottled rock in which porcelainous tabular phenocrysts of plagioclase and dark hornblende and biotite are set in a faintly pink matrix. Many exposed surfaces show tabular pits left by the differential weathering of plagioclase phenocrysts. In general the porphyritic granodiorite is very homogeneous. Diorites and low-potash granodiorites (tonalite) are the most marked variants, but are of limited occurrence.

Mineral compositions of porphyritic granodiorite specimens are shown in Table II, columns 1 to 7 and 9. Column 8 is an average of columns 1 to 7. Column 9 is an analysis of a specimen from Stevenson, 1947 (pp. 439–441), and a chemical analysis of this specimen is included.

* Classification according to Turner and Verhoogen, 1951, pp. 61–65.

Table II.—Modal (Volumetric) Analyses of Rocks of Rocher Deboule Stock Porphyritic Granodiorite and Quartz Monzonite

	1	2	3	4	5	6	7	8	9	10	11	12
Quartz	17.0	23.1	14.5	29.0	17.0	20.8	16.6	19.7	20	19.4	24.4	21.9
Potash feldspar	21.9	20.3	21.1	32.0	18.1	21.9	17.1	21.8	19	42.5	33.0	37.8
Plagioclase	46.1	45.3	45.7	31.3	51.5	39.3	58.5	45.4	47	33.4	37.1	35.2
Hornblende	9.2	6.4	9.6	5.1	8.6	12.8	6.2	8.3	9	......	......	......
Biotite	5.8	4.3	9.1	2.6	2.7	4.2	tr	4.1	3	4.7	5.5	5.1
Iron ores	tr	0.7	tr	tr	2.7	1.0	0.8	0.7	2	......	......	......
Sphene	tr	tr	tr	tr	tr	tr	0.6	0.3	......	......	......	......

Chemical Analysis of Specimen 9[1]

	Per Cent		Per Cent
SiO_2	64.58	K_2O	2.81
Al_2O_3	15.74	H_2O-	0.10
Fe_2O_3	1.67	H_2O+	1.49
FeO	2.43	TiO_2	0.57
MgO	1.97	P_2O_5	0.20
CaO	4.48	MnO	0.056
Na_2O	3.73	BaO	0.10

[1] From Stevenson, 1947, pp. 440–441, analyst, G. C. B. Cave.

Specimen No.	Location
1.	Head of north branch of Brian Boru Creek.
2.	Head of south branch of Straw Creek.
3.	Northwest slope of range, above Seeley Lake.
4.	Ridge between Straw and Corya Creeks.
5.	Ridge between two branches of Straw Creek.
6.	Lower Chicago Creek.
7.	Head of Mudflat Creek.
8.	Average of 1 to 7, porphyritic granodiorite.
9.	Specimen from head of Red Rose Creek (from Stevenson, 1947, p. 439).
10.	Middle part of Station Creek.
11.	Rock drumlin on bench southwest of New Hazelton.
12.	Average of 10 and 11, fine-grained quartz monzonite.

Microscopically, the porphyritic granodiorite is formed of 20 to 35 per cent of plagioclase phenocrysts about 4 by 4 by 2 millimetres on the average, the largest being about 10 by 10 by 5 millimetres. These phenocrysts invariably show oscillatory zoning; a central portion with an anorthite content of about 40 per cent* is surrounded by four or five major oscillatory zones and a rim with an anorthite content of about 20 per cent. Hornblende and biotite are both invariably present, with hornblende usually twice as abundant as biotite. Total mafic minerals are rarely over 15 per cent. Matrix is formed of plagioclase, slightly perthitic orthoclase, and quartz. Commonly the small plagioclase grains are fairly euhedral and slightly zoned (about An_{20}), whereas quartz and orthoclase are anhedral. Plagioclase and orthoclase, or orthoclase and quartz may bear subophitic relationships to one another. In some instances the feldspars have myrmekitic or fretted borders with quartz, in others simple microgranitic texture. Accessory minerals include in order of decreasing abundance, iron ores, sphene, apatite, zircon, and rarely fluorite. Sphene in some specimens may be as abundant as iron ores. Each may form ½ to 1 per cent. Most minerals are fresh, but hornblende and biotite may be partly altered to chlorite and feldspar may be slightly kaolinized or sericitized.

Variant Types

The main variations from the normal porphyritic granodiorite are volumetrically insignificant and appear to be restricted to localities adjacent to the roof of the stock. Two chief variants are tonalite and diorite of variable texture and composition.

Tonalite occurs in the cirque at the head of Armagosa Creek. This rock is not noticeably porphyritic macroscopically and is darker grey than the normal

* All optical feldspar determinations were made on combined Carlsbad-Albite twins.

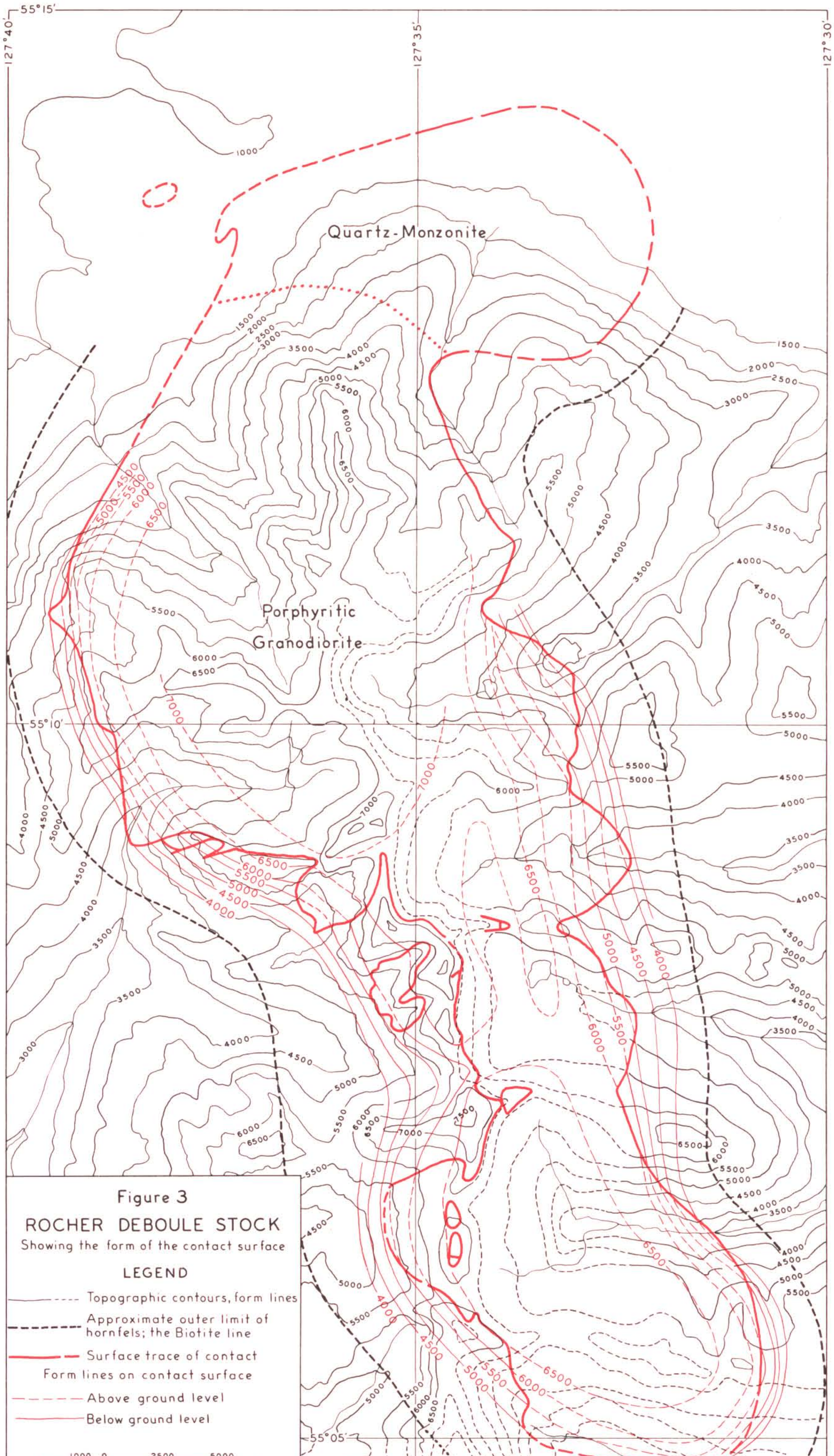


Figure 3
ROCHER DEBOULE STOCK
Showing the form of the contact surface

#43
①

granodiorite because the feldspars are dark. Microscopically it is slightly porphyritic with plagioclase phenocrysts (An_{37-32}) forming about 50 per cent of the rock and hornblende, the only mafic mineral, forming about 15 per cent. The matrix consists of nearly equal amounts of quartz and plagioclase (15 per cent of the rock each) and 5 per cent orthoclase. Iron ores and sphene are subequal in amount and form together about 1 per cent of the rock. Other accessories include zircon, apatite, and fluorite.

Diorite of variable grain size and composition outcrops on the ridge between Mudflat and Porphyry Creeks. Most of the area exposes medium-grained, mid-grey, rusty weathering diorite; however, the rock varies erratically to similar but finer-grained diorite, to more mafic rock, or to normal granodiorite. Microscopically, the most common type is formed of about 70 per cent labradorite in slightly and simply zoned subhedral grains. Hornblende in patchy composite masses containing some interstitial biotite forms about 25 per cent of the rock, iron ores and sphene each form about 1 per cent, and quartz forms 1 to 5 per cent. Some zoisite occurs as an alteration product of hornblende and possibly plagioclase.

Inclusions

Inclusions in the porphyritic granodiorite are ubiquitous. In the main mass away from the contacts they may form about 1 per cent of the rock and be no bigger than 1 foot in diameter. Near the roof they generally form 2 to 4 per cent or more of the rock and rarely may be 20 to 40 feet long. Corresponding to the difference in amount there is a difference in character. Those near the roof may be angular and recognizable as to origin, whereas those remote from the roof are almost all rounded and finely dioritic. At the head of the north branch of Brian Boru Creek inclusions are particularly numerous adjacent to the conglomerate; some are angular blocks of large size and some are incorporated boulders from the conglomerate. In many localities not near the roof, inequant rounded inclusions are mostly oriented with their long dimension approximately vertical. In summary, the inclusions decrease in quantity, angularity, recognizability, and size, away from the roof.

Fine-grained Quartz Monzonite

The second rock type of the Rocher Deboule stock is a fine-grained, buff-coloured, biotite quartz monzonite. The quartz monzonite appears fairly homogeneous, but there is more variation in relative abundance of minerals than in the granodiorite. Mineral composition of two similar looking specimens is shown in Table II, columns 10 and 11. Both are quartz monzonites, but there is a wide variation in the ratio of plagioclase to potash feldspar. Microscopically the quartz monzonites are composed of potash feldspar, plagioclase (An_{30-10}), quartz, and biotite, usually in that order of abundance, although the relation between the feldspars may be reversed, perhaps because of unequal distribution of the rare plagioclase phenocrysts (or xenocrysts). These phenocrysts normally have a thick mantle of slightly perthitic orthoclase. The potash feldspar is normally slightly perthitic orthoclase, but may be microcline. Commonly there is some micropegmatitic and myrmekitic textural relations between the feldspars and the quartz. Accessory minerals include apatite and zircon; iron ores are minor, and sphene rare. Hornblende is never present. Specimens from near the northern contact contain large irregular grains of zoisite. The average grain size of the matrix is about 0.5 millimetre.

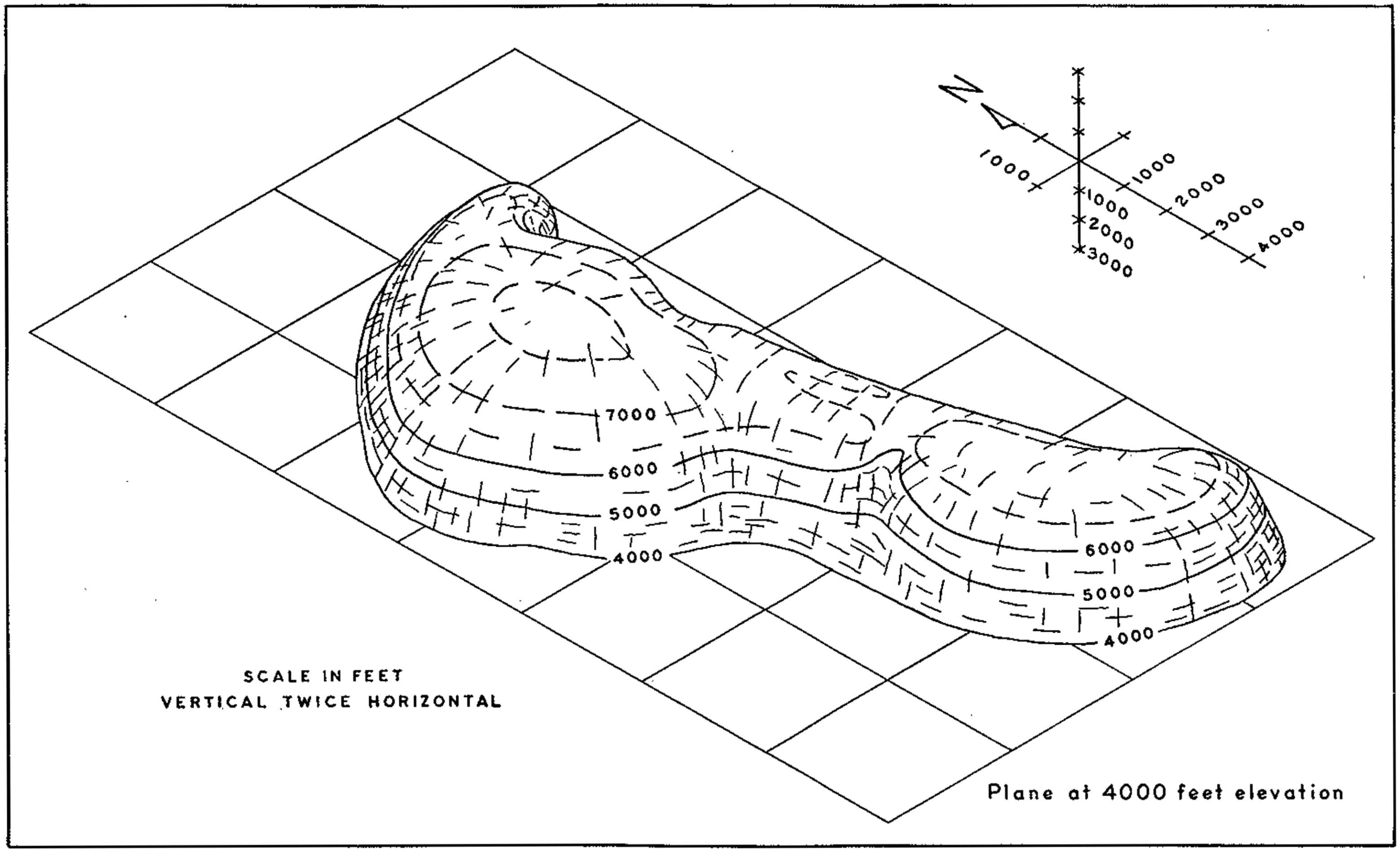


Figure 4. Isometric sketch of Rocher Deboule stock.

Structure

The structure of the upper part of the Rocher Deboule stock is relatively well known because erosion has exposed the roof of the stock in the peaks of the range and in the deep cirques on the flanks. The following discussion is mainly concerned with the porphyritic granodiorite which forms almost 90 per cent of the stock and occupies the area of greatest relief and best exposure.

The stock is clearly intrusive. The granodiorite cuts cleanly across the fold structures of the Hazelton group and seemingly has not caused any folding or other deformation of the older rocks (*see* Fig. 2). Decipherable contact details are also chiefly indicative of intrusion.

Contact relations of the quartz monzonite are not as clear because thermal metamorphism of the feldspathic greywackes of the Hazelton group has produced a rock not very different in hand specimens from the quartz monzonite. This makes the contact appear gradational. Nonetheless there are localities on the glaciated rock drumlins on the bench southwest of New Hazelton where definite intrusive relations show.

The contact between granodiorite and quartz monzonite is gradational over a zone hundreds of feet wide and is poorly exposed. The gradational nature of the contact is probably indicative of a close temporal relation. Two facts suggest the quartz monzonite is the younger phase. Firstly, specimens of quartz monzonite with mantled plagioclase phenocrysts are commonest adjacent to the granodiorite. Secondly, a few quartz-monzonite dykes, such as the Rocher dyke of the Rocher Deboule mine (*see* pp. 36 and 61), are known in the granodiorite, although none has been traced from the contact.

Shape of the Rocher Deboule Stock

The stock is an elongate pluton, a composite of two domes with a connecting saddle, oriented north 25 degrees west. The domes and saddle are slightly asymmetrical, with crests closest to the west side and longer and more gentle slopes on the east side. The roof is exposed along part of the central spine of peaks, at the head of Red Rose Creek, and on the pendants on the cross ridges and central arête (*see* Plate VII). Local relief is 3,000 to 4,000 feet so that details of the walls are readily apparent on the areal map. The relief at the north end of the range is 5,500 feet. Figure 3 shows the outline of the stock together with contours on the surface of contact with older rock (cf. Fyles, 1955, pp. 28–29, and Fig. 3). Structural cross-sections (Fig. 6) also indicate the shape of the stock. Figure 4 is an isometric sketch of the stock down to the 4,000-foot contour using the same data and making suitable interpretations. Below this level the only information is on the north face of the range and there the same shape continues downward. As foliation is very rare, conjecture on the shape of the lower part of the stock is unwarranted. The shape shown for the saddle and south dome is believed to be accurate, but it is not certain that the northern dome is as simple as it seems. For one thing the northeastern bulge, formed by the quartz monzonite, may be unrelated in form to the rest of the stock. Complications introduced by faults are ignored in Figure 4 as they do not affect the over-all shape.

Although the over-all shape of the stock is smooth, the actual contact may be quite irregular. Small and large dykes of granodiorite and related rocks at some localities extend from the main mass short distances into the older rocks. In the basin at the head of the north branch of Brian Boru Creek where the granodiorite cuts conglomeratic rock there are particularly clear examples of dilation dykes, stoped blocks, and incorporated boulders. Several examples were noted of small dykes with fitting walls between which were angular fragments of wallrocks that must have been flushed from elsewhere. Large dilation dykes were noted in the cirque walls above the head of the north branch of Straw Creek and on the ridge between Armagosa and Juniper Creeks. The latter are large enough to show on the areal map. They are recurving and apparently isolate large blocks of older rocks. The contact in the vicinity of the Victoria property is step-like, with bedding planes of the hornfels forming the treads.

In general the granodiorite is neither foliated nor lineated. Two exceptions are known. On the northeastern face of the range there is a foliation parallel to the contact and a steeply plunging lineation. At a locality near the southwestern end of the stock a faint lineation of hornblende crystals strikes at right angles to the contact and plunges gently beneath it.

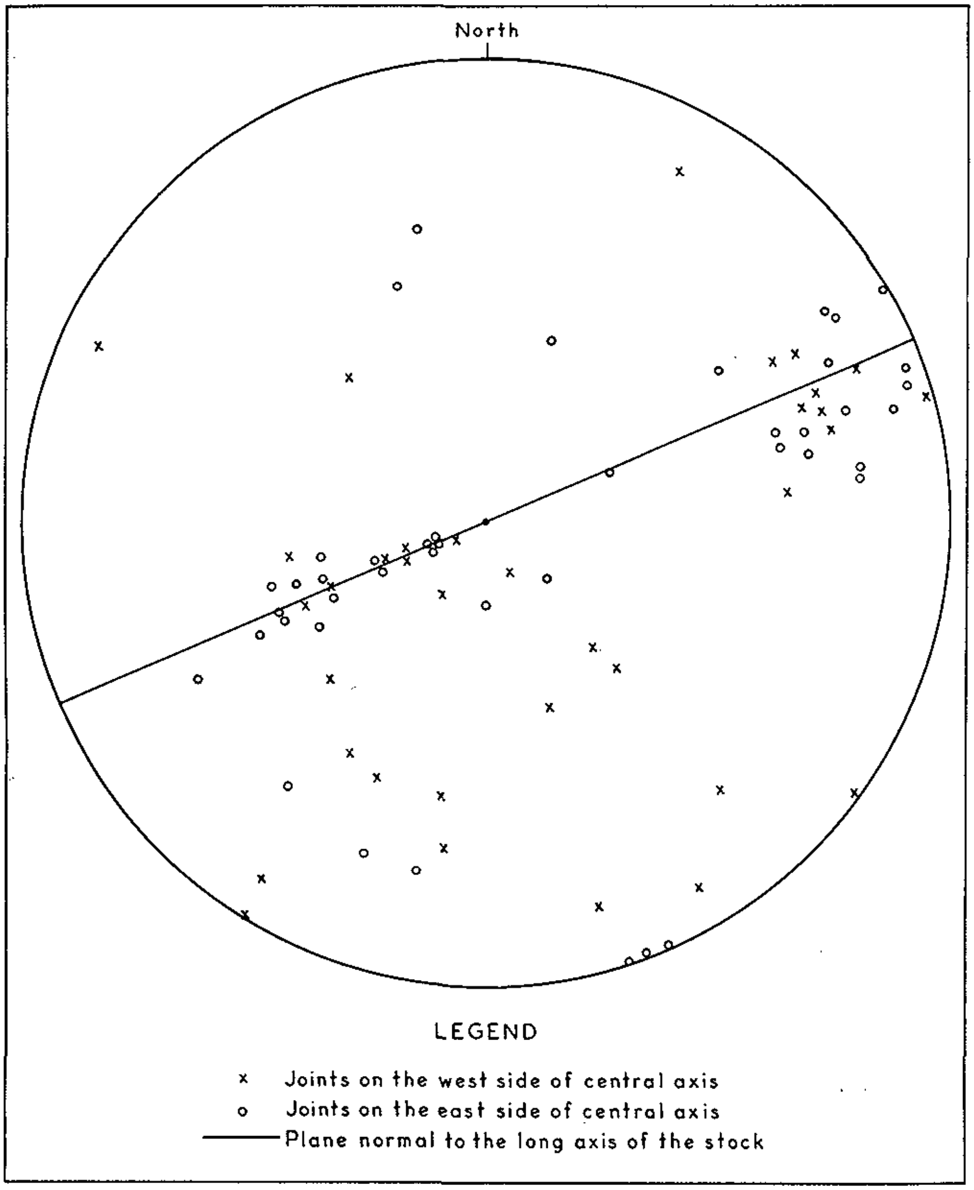


Figure 5. Projection on a Schmidt stereonet of joints observed in the Rocher Deboule stock.

Joints

Jointing throughout the granodiorite is pronounced, regular, and patterned. Joints are commonly 2 to 10 feet apart and some are continuous for thousands of feet. In general, there are three sets of joints, of which two are most pronounced and regular. These are: (*a*) parallel to the contact, and (*b*) normal to the contact and making a horizontal trace on the contact surface (cross-joints). The third and least well-developed set is normal to the first two and hence is radial and dips vertically. The joint pattern, and its relationship to the contact surface, is most readily seen in the area between the top of the two domes, but appears general even though the data at the ends of the stock are scant. The orientation of the first and second sets of joints is seen in the cross-sections (Fig. 6) and the second and third sets in Figure 4. Plate VII shows topography guided by flat joints parallel to the roof on Straw Creek. Figure 5 is a stereographic projection on a Schmidt net of the poles to the joints which are plotted on the areal map, Figure 2. In the field it was found sufficient to plot one joint to represent a fairly large area and consequently the figure is more authoritative than the number of poles suggests. Even so, the observations were too few and too unevenly distributed to be fully representative. For example, joints in the western side of the stock are not fully represented chiefly because more of the western slopes are covered, but also because of the lower density of observations. Recorded joints at the north and south ends are also too few. Nevertheless the poles show a well-defined girdle oriented normal to the long axis of the stock. These represent the joints parallel to the contact and those normal to it that make a horizontal trace on the contact surface, in all but the ends. In the absence of direct observation of the roof the joint pattern can be used to judge its position. This pattern confirms the gentle dome-like shape of the northern protrusion.

The joints are rarely filled with aplite, pegmatite, or other dykes. Near the upper end of Juniper Creek minor aplites and pegmatites are found in the joints. In other places they are very rare and nowhere are they large. One could surmise that the joints formed late or that magma pressures may have relaxed after emplacement.

Evidence bearing on the origin of the joints includes the lack of pegmatites, the lack of foliation, the lack of evidence of intense forceful intrusion, and the fit of the pattern to the shape of the stock. These facts probably indicate that the joints were caused by cooling contraction.

Emplacement and Petrogenesis

The mode of emplacement of the Rocher Deboule stock is relatively certain. The granitic rocks of the stock are unfoliated and cut cleanly across the fold structures of the older rocks, therefore emplacement has been post-tectonic and relatively passive. Thermal metamorphism of the older rocks conforms in outline to the shape of the stock. Large and small networks of dilation dykes are common in the wallrocks, and inclusions in the stock are widespread, but most abundant near the contact. External granitization is limited and local. The evidence indicates emplacement by intrusion of a fluid magma, probably by piecemeal stoping.

The ultimate origin of the magma is unknown, but certain similarities between the Brian Boru flows and the Rocher Deboule stock lead to speculation as to whether they might not have the same origin. The similarity in composition and oscillatory zoning of the plagioclase phenocrysts of flows and plutonic rocks is striking and the difference in bulk composition of the flows and plutonic rocks is slight. Incidentally incorporated material from the flows, or from sedimentary rocks derived from them, would not greatly change the bulk composition of the stock.

Age

The stock intrudes the Brian Boru formation of post-Aptian age (mid-Lower Cretaceous). Its relation to the sedimentary rocks near Moricetown is not directly known, but the latter are completely unmetamorphosed and essentially in place in the valleys in which they were deposited, hence the sedimentary rocks seem younger than the stock. However, most of the pebbles and cobbles in the Moricetown strata are porphyry, no granodiorites were noted, and thus the stock was not unroofed prior to the deposition of the strata in Paleocene or Late Cretaceous time. Hence the stock was probably emplaced between mid-Lower Cretaceous and late Upper Cretaceous.

METAMORPHISM

Rocks of the Hazelton group have been thermally metamorphosed during emplacement of the Rocher Deboule stock. An aureole with outwardly decreasing intensity of metamorphism surrounds the stock (*see* Fig. 3), and beyond this zone of noticeable metamorphic effects, sedimentary rocks have been generally hardened. Only in the southwestern part of the map-area, and beyond the Rocher Deboule range, are the sedimentary rocks unmetamorphosed and poorly lithified.

In general appearance the fine-grained sedimentary rocks have been most affected by metamorphism and the andesites least, but the new mineral growth in both rocks occurs at approximately the same distance from the stock. Outside the biotite zone (*see* Fig. 3) the shales and siltstones have been hardened, bedding and lamination have been partially erased, and some rocks have been bleached, whereas the greywackes and andesites have been little affected. Within the biotite zone some shales appear as unbedded, rusty weathering yellow-grey argillites that break upon weathering to small angular fragments, whereas others remain dark grey but are spotted. Argillaceous rocks closer to the stock take on a pervading purplish-chocolate colour and become dense hornfelsic rocks with semi-conchoidal fracture. In the greywackes the effects of metamorphism are not obvious except for some hardening until well within the biotite zone where the growth of biotite begins to colour the rock a purplish-chocolate. The porphyries are hard whether they are metamorphosed or not so that the only noticeable macroscopic effect is the colouring near the contact. At the actual contact some bleaching, metasomatism, or in rare instances granitization, may be observed in various rocks. In a few localities where andesites form the roof of the stock the contact appears to be gradational over 20 feet or so, but the contact is readily apparent on microscopic examination.

Microscopically, it is evident that the most widespread metamorphic change is the growth of biotite. A line shown on Figure 3 represents the outer limit at which new biotite has been observed. This biotite line is 2,000 to 5,000 feet horizontally outside the granodiorite contact. The enclosed zone is widest west of the saddle of the stock where the granitic rocks occur at relatively shallow depths over a moderate area (*see* Fig. 3). Beyond this line, microscopic growth of chlorite and sericite has bonded matrix to fragments and some carbon has been either fixed as graphite or driven off. Inside the line all types of rocks show progressive growth of biotite toward the stock. Cordierite is a common associate of biotite in the argillaceous rocks, particularly in the spotted varieties. In the arenaceous and porphyritic rocks the biotite first grows in the matrix, but with intense metamorphism biotite begins to replace the large grains of feldspar. Only a few examined specimens of any type from within the biotite line show no biotite, and these have muscovite and epidote.

Higher-grade minerals such as zoisite, amphibole, pyroxene, garnet, sillimanite, and axinite are more erratically distributed than biotite and do not form concentric high-grade zones between the biotite line and the granodiorite contact. In almost all instances biotite occurs in the presence of these high-grade minerals, but in some specimens it is clearly being replaced by them. The various remnants of the roof and the veneer of wallrocks on the northeastern face of the range are characteristic high-grade areas. Argillaceous rocks may be changed to biotite-quartz-axinite rocks with some large poikilitic garnet porphyroblasts or simply to a rock formed of biotite, muscovite, quartz, and new feldspar. Greywackes at the contact may also be changed to garnet-biotite-quartz-axinite rocks of crystoblastic texture. Normally greywackes are less changed, with the matrix recrystallized to biotite, zoisite, and fibrous sillimanite, but with detrital quartz grains unaltered and detrital feldspar and porphyry fragments in various stages of reconstitution, involving growth of muscovite, epidote, biotite, amphibole, and new feldspar. The porphyries are somewhat similar to the greywackes; metamorphism consists mainly of reconstitution of the matrix with relatively less change occurring in the feldspar phenocrysts. The matrix first has growth of biotite. In higher-grade zones the biotite may be partly or wholly replaced by green amphibole. Some zoisite may occur, and combined grains of amphibole, sphene, and iron ores. Rarely hornblende has been recrystallized to pyroxene. Commonly some quartz has crystallized in the matrix. Phenocrysts of feldspar may be quite fresh or be altered in a manner similar to feldspar in the greywackes.

Metasomatism

Metasomatism about the stock does not seem to be important as a whole. Some metasomatism close to the contact is indicated by growth of tourmaline and apatite, widely distributed in all types of rocks in minor amounts. Two types of pyritization occur about the stock; their connection with the thermal metamorphism is not certain. In the first type pyrite is widely distributed in minor amounts in the hornfelsic shales. Judging by inclusions in the pyrite it has grown, and commonly in the form of small spherules with some concentric structure rather than as cubes. Both iron and sulphur were present in the unmetamorphosed rocks and there is no assurance that there has been anything more than local concretionary growth induced by the thermal metamorphism. The other type of pyritization represents definite addition of iron and sulphur to the rocks. The largest such locality is at the southern end of the Rocher Deboule stock on Corya Creek where Brian Boru andesites and the outer part of the pluton have both been affected. The pyrite forms 5 to 10 per cent of the rock and may contain traces of chalcopyrite.

DYKES YOUNGER THAN THE PORPHYRITIC GRANODIORITE

Dykes of a number of rock types occur within the Rocher Deboule porphyritic granodiorite and some can be recognized beyond it. Five types of dykes are known well enough to describe. These are aplite and pegmatite, granitoid dykes, porphyritic andesite, felsite, and basic dykes. The age relation of these types is not clear as some are not in contact and others have ambiguous relations. They are dealt with in a general order of older to younger.

1. Aplites and pegmatites occur sparingly throughout most of the stock. Most of them are small in size. In places where they are relatively abundant, as they are around the Silvertip glacier, they are of at least two ages. The principal veins of the area are pegmatitic veins which have been modified by replacement by sulphides. The aplites, pegmatites, and pegmatitic veins have ambiguous relations with the granitoid dykes and probably overlap in age.

2. Granitoid dykes are widely distributed and may be as much as 100 feet wide. Most are much smaller and are not volumetrically very important. They are somewhat variable in aspect but many resemble the Rocher dyke of the Rocher Deboule mine. This is a fine-grained quartz-monzonite dyke composed originally of about 35 per cent albitic plagioclase, 20 per cent orthoclase, 10 per cent quartz, 5 per cent micrographic granite, 20 per cent hornblende now altered to chlorite, with some epidote, calcite, and leucoxene. This rock resembles the quartz-monzonite phase of the stock and so it may indicate the quartz monzonite is younger than the granodiorite. Some other dykes included are somewhat coarser grained or contain more dark minerals than the Rocher dyke and might be classed as diorites or syeno-diorites. Such dykes are found in the Victoria and Rocher Deboule mines. All these types are relatively early post-granodiorite dykes.

3. Porphyritic andesites or feldspar porphyries which are found within the stock would be classed with the dykes of Brian Boru affiliation if found outside (*see* pp. 22 and 26). However, they differ from the Brian Boru " dykes " in being less porphyritic and more trachytic. These porphyries are younger than the granitoid dykes and older than the felsites. They are purplish dark grey aphanitic rocks containing about 20 per cent tabular andesine phenocrysts and 5 per cent hornblende phenocrysts in a fine matrix of feldspar laths, biotite, minor quartz, and iron ores. Many of them are trachytic. These dykes are known on the Victoria, Red Rose, and Rocher Deboule properties and elsewhere.

4. Clearly much later than the granitoid and porphyritic andesite dykes are felsites which are shades of middle grey, sometimes with a greenish tinge when fresh, but which weather a buff colour. These are aphanitic rocks with rare small phenocrysts of feldspar or more rarely quartz. Most of them are composed of a felted mass of oligoclase which forms 60 per cent of the rock, and hornblende which forms 15 per cent, with interstices between these minerals filled with chlorite, quartz, and iron ores. On weathering, the felsites commonly break into conchoidal slabs and many have a conchoidal fracture when freshly broken. These dykes may be 30 feet wide but most are much less, those in the Red Rose, Rocher Deboule, and Victoria mines being 1 to 10 feet wide. In these mines, dykes are clearly younger than the veins.

5. Dykes of the last group are poorly known because they are rare. All are small, dark, fine-grained to aphanitic dykes but probably they include fine-grained biotite lamprophyres and basalts. Both types are late dykes and both are small and rare. The basaltic ones may be related to the Tertiary flows near Moricetown.

SEDIMENTARY AND VOLCANIC ROCKS NEAR MORICETOWN

Sedimentary and volcanic rocks younger than the Hazelton group are exposed in the Bulkley Valley along the canyon below the Moricetown falls, along cuestas at the western side of the valley, and at some isolated knolls projecting above the valley fill. A lower unit is composed of greywacke and shale that occurs in two basins exposed only along the canyon from Moricetown falls to the mouth of Corya Creek and from just south of Straw Creek to just south of Porphyry Creek. These rocks contain fossil plants of Paleocene or Late Cretaceous age. An upper unit consists of basic lavas and dykes that overlie and intrude the sedimentary rocks. The volcanic rocks may be about the same age as the sedimentary rocks or considerably younger. Formational names are not proposed because too little is known about similar rocks that occur in greater quantity southeast of the map-area.

Much of the original confusion about the Hazelton group and the Skeena formation arose because W. W. Leach (1909, pp. 62–64; 1910, p. 94) failed to distinguish the Moricetown sedimentary rocks from similar rocks belonging to the

Hazelton group, particularly member A of the Red Rose formation. Leach's description of the structural relations between the Hazelton and Skeena formations was based actually on that between Hazelton and Moricetown rocks.

Sedimentary Rocks

The sedimentary rocks outcrop only along the small canyon of the Bulkley River, from just south of the Moricetown falls for 2 miles to the north and again for about 3 miles north from Seaton station. The strata appear to be 400 to possibly 500 feet thick but possibly the beds had high initial dips so that the total thickness of fill in the sedimentary basin may have been less. The relationship to the Hazelton group must be unconformable but the actual contact was not seen. The adjacent structures are very discordant throughout, and though this is partly explained by faulting along the Bulkley Valley, the discordance cannot be wholly explained this way. The Moricetown sedimentary rocks are intruded by dykes identical to overlying basic flows.

The unit is composed of poorly lithified greywacke and shale with some conglomerate, all of which are shades of middle grey to black. Beds range from a few inches to 5 feet thick and are commonly about a foot thick, alternating between greywacke and shale. Carbonized logs, branches, and twigs are common throughout (*see* Plate IX) and some coaly beds and some carbonaceous shale occur. In a few localities bedding planes are charged with leaf impressions. The greywacke beds contain rare angular volcanic fragments about one-half inch in diameter. Cut and fill structures and wave ripple marks occur. The cuts noticed were oriented roughly parallel to the valley and were filled with pebble conglomerate. Conglomerate occurring in more extensive beds is mostly pebble conglomerate but contains cobbles in some places. Most pebbles and cobbles are composed of porphyry similar to the Brian Boru rocks but about 10 per cent are argillite. Pebbles are well rounded but not spherical. No granodiorite pebbles were seen. The rocks as a whole resemble member A of the Red Rose formation, but are not as well lithified.

The age of these strata is either Paleocene or Late Cretaceous, more likely the former. Plant leaves collected by Kindle were examined by W. A. Bell, who suggested the above ages. At presumably the same locality north of the falls the writer collected the following:—

Meta sequoia occidentalis (Newberry) Chaney.
Cercidiphyllum articum (Heer) Brown.
Juglans sp.
Acer sp.

These were identified by W. L. Fry, who suggested they indicated a Paleocene age.

Volcanic Rocks

Andesitic to basaltic volcanic rocks intrude the sedimentary strata and overlie them either conformably or slightly unconformably. These rocks occur at the Moricetown falls, as a series of lens-like dykes further downstream (*see* Plate IV), and as cuestas flanking the Bulkley Valley bottom on the west from about Doughty station south of the map-area to north of Corya Creek. The lava flows are at least 200 feet thick.

These rocks are black to dark greenish-grey on fresh surfaces and are commonly dark brown on weathered surfaces. They are aphanitic to microporphyritic rocks with abundant calcite amygdules in places. Columnar jointing is present in some of the cuesta localities, with columns normally 6 inches in diameter. Tops of brecciated flows are evident locally. The lens-like dykes have baked adjacent sedimentary rock for 10 to 40 feet from the contact.

The rocks from all localities are similar microscopically, being composed of microphenocrysts of labradorite and pyroxene in a matrix of trachytic labradorite laths. The interstices are filled with small pyroxenes, iron ores, and dark semi-opaque material of glassy or chloritic nature. The pyroxene phenocrysts are partly or wholly altered to chlorite. The percentage of phenocrysts ranges from less than 5 per cent to about 20 per cent. These rocks may be basalts but are probably best considered as andesites.

Structure

The sedimentary and volcanic rocks near Moricetown occur in two separate localities and may have been laid down in two separate basins. It is more likely, however, that they were laid down in one basin which has since been divided by faulting and erosion. The over-all structural pattern is that of a gentle syncline or sag parallel to the Bulkley Valley, with strata and flows dipping gently into the valley. This pattern is disturbed by minor faults and by folds related to them. The volcanic rocks at the western side of the valley dip about 15 degrees to the east or northeast and the sedimentary strata and flows near the falls and for 1½ miles downstream dip mostly 15 to 30 degrees to the west or southwest. These dips toward the centre of the valley may be initial dips or may be the result of tilting toward a sinking or graben-like central part of the valley.

This major structure is disturbed locally by more intense deformation. Toward the north end of the Moricetown basin a seemingly small fault which greatly disrupts the main pattern is seen in the west bank where it strikes about east and dips and flattens northward. Strata are subparallel to the fault immediately above it, but are sharply truncated below it. North of the fault sharp folds of about 100 feet amplitude trend parallel to the fault strike and are broken by a number of subsidiary faults. The east bank of the creek does not seem to be disturbed by the fault. The pattern of faults and folds seems to indicate a slide from the north or northwest possibly off the shoulder of Hazelton rocks that separates the rocks of the southern from the northern basin.

CHAPTER III.—STRUCTURAL GEOLOGY

The Rocher Deboule Range is a fairly homogeneous structural unit. Folding is moderate, with bedding dips as a rule less than 45 degrees, but details of the pattern are complicated. Folding was completed prior to emplacement of the Rocher Deboule stock. The external shape and internal structure of the stock are moderately simple. Three large normal faults striking slightly west of north divide the range into four fault blocks. In addition, large faults probably isolate the range from adjoining mountain masses.

FOLDS

The Hazelton group appears to have been folded as a unit and no significant internal unconformities were observed. All folds in the vicinity of the stock are truncated by it and none appears to have been modified by the forces of intrusion. A small anticline on upper Station Creek is so oriented that it could have been formed or modified by the intrusion, but there is no direct evidence that it was. Folds are characteristically open and bedding generally dips less than 45 degrees. Steeper dips are rare and overturned attitudes limited to one locality south of Red Rose Creek.

The major fold of the range is a large scoop-shaped syncline with diverging limbs and an axis trending about north 55 degrees east and plunging 10 to 20 degrees northeast (*see* Figs. 2 and 7). The plunge decreases to the northeast from near Brian Boru Peak toward the Bulkley Valley. Although this syncline is larger than other folds it is less noticeable than the more important subsidiary folds. The north limb of the main syncline trends north 10 to 20 degrees east and the other limb trends about south 80 degrees east. The subsidiary folds are parallel to these diverging limbs. Figure 2 shows subsidiary folds on the northern limb, but only one north facing limb of an anticline on the south limb of the major syncline. Most of the " southern limb " folds are south of the map-area along Rocky Ridge (*see* Fig. 1 and Map 44-23).

Figure 7 is a contoured stereographic projection made in illustration of the structure. It represents 100 poles to bedding planes which are distributed about one per square mile. The scarcity within the map-area of subsidiary folds on the southern limb is apparent. If the lack of data is made up from observations beyond the map-area the plot will show three girdles (pole circles) representing the main syncline and the secondary folds. The minor folds are symmetrical with respect to the major fold.

The largest of the north trending subsidiary folds is the peculiarly shaped anticline east of Juniper and Brian Boru Creeks (*see* Fig. 6, Section C-C′). This anticline is overturned toward the east at ground level, but not in its upward continuation and probably not downward. Other folds in the mountains are relatively gentle and all plunge northeastward at about 10 to 20 degrees. In the Skeena Valley near Seeley Lake the folding is somewhat more intense than in the mountains.

The pattern of folding in the Rocher Deboule area is not simple, but there is nothing to indicate that two periods of deformation are involved. The pattern indicates that the folding was not a simple compression. This suggestion is strengthened by consideration of the regional fold trends.

Fold axes in the Hazelton and Skeena Mountains swing in a large smooth curve. They trend eastward from a point southwest of the junction of the Kitseguecla and Skeena Rivers and swing through northeastward in Rocher Deboule, Nine Mile Mountain, Blunt Mountain, and Hazelton Peak to northwestward in Mount Thomlinson, Atna Range, and the main mass of the Skeena Mountains (*see* Fig. 8). The trend of the folding in the Rocher Deboule Range was not clear on Map 44-24, nevertheless Armstrong (1944b, Map 44-24) was able to conclude:—

"Within each local mountain range the bedded formations have been folded in a fairly uniform direction, which, however, in most places, does not persist across intervening valleys to neighbouring ranges. Further, the sedimentary strata in the main valleys are intensely deformed and the structures there exhibit no regular pattern. These facts suggest that the principal valleys lie along major fault zones, and, that each individual mountain range or massif, as for example Rocher Deboule Range, may represent a fault block."

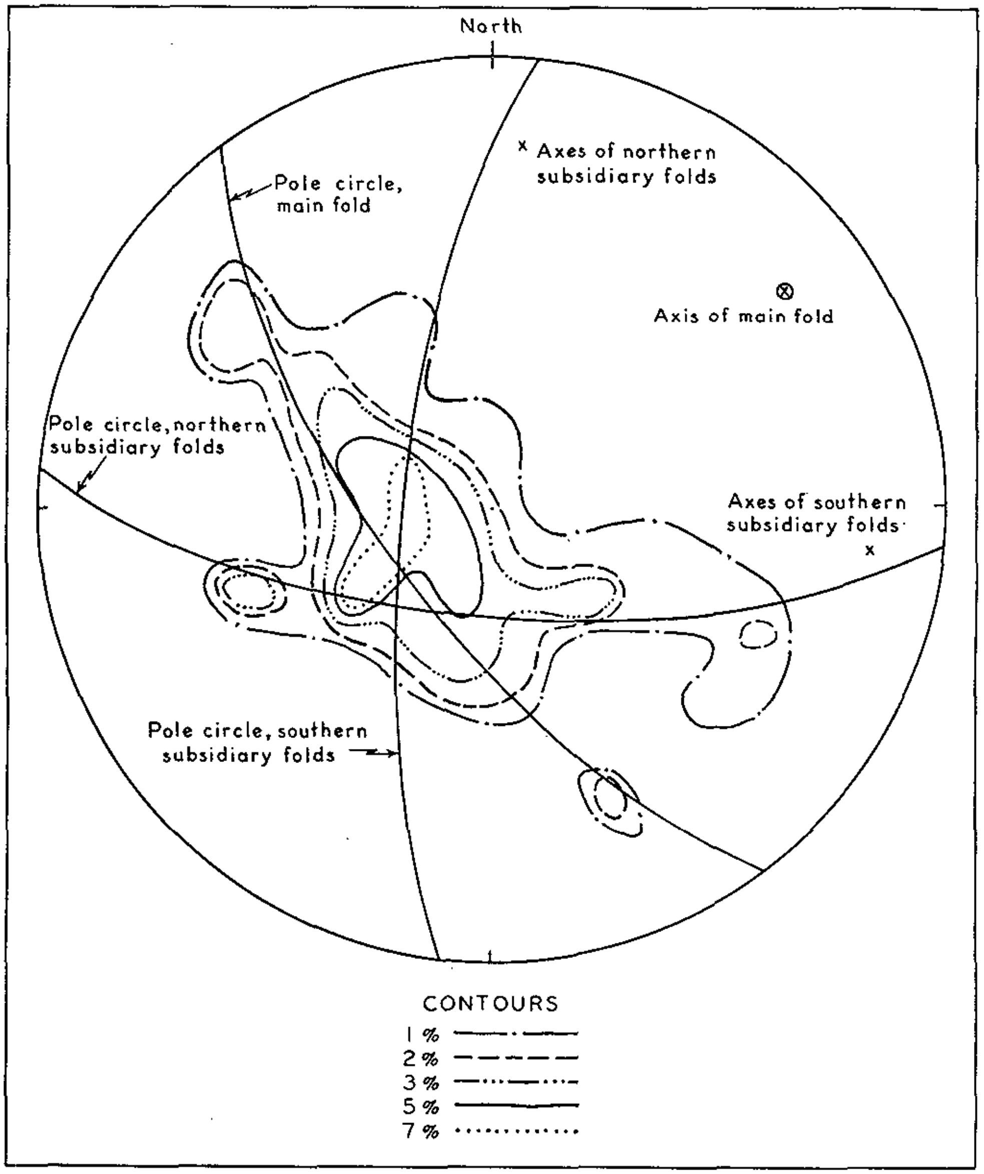


Figure 7. Contour diagram of a plot on a Schmidt stereonet of 100 poles to bedding, distributed about one per square mile.

Clarification of the fold trends in the Rocher Deboule Range enables one to see on studying Map 44-24 that this smooth curve exists and that Rocher Deboule represents a point of major flexure. However, Armstrong's conclusion suggesting that each range or massif is a separate fault block is possibly correct (*see* Faults, pp. 42 and 43).

The Rocher Deboule stock cuts cleanly across the folds in the Hazelton group and apparently has caused little or no external deformation. The stock itself is

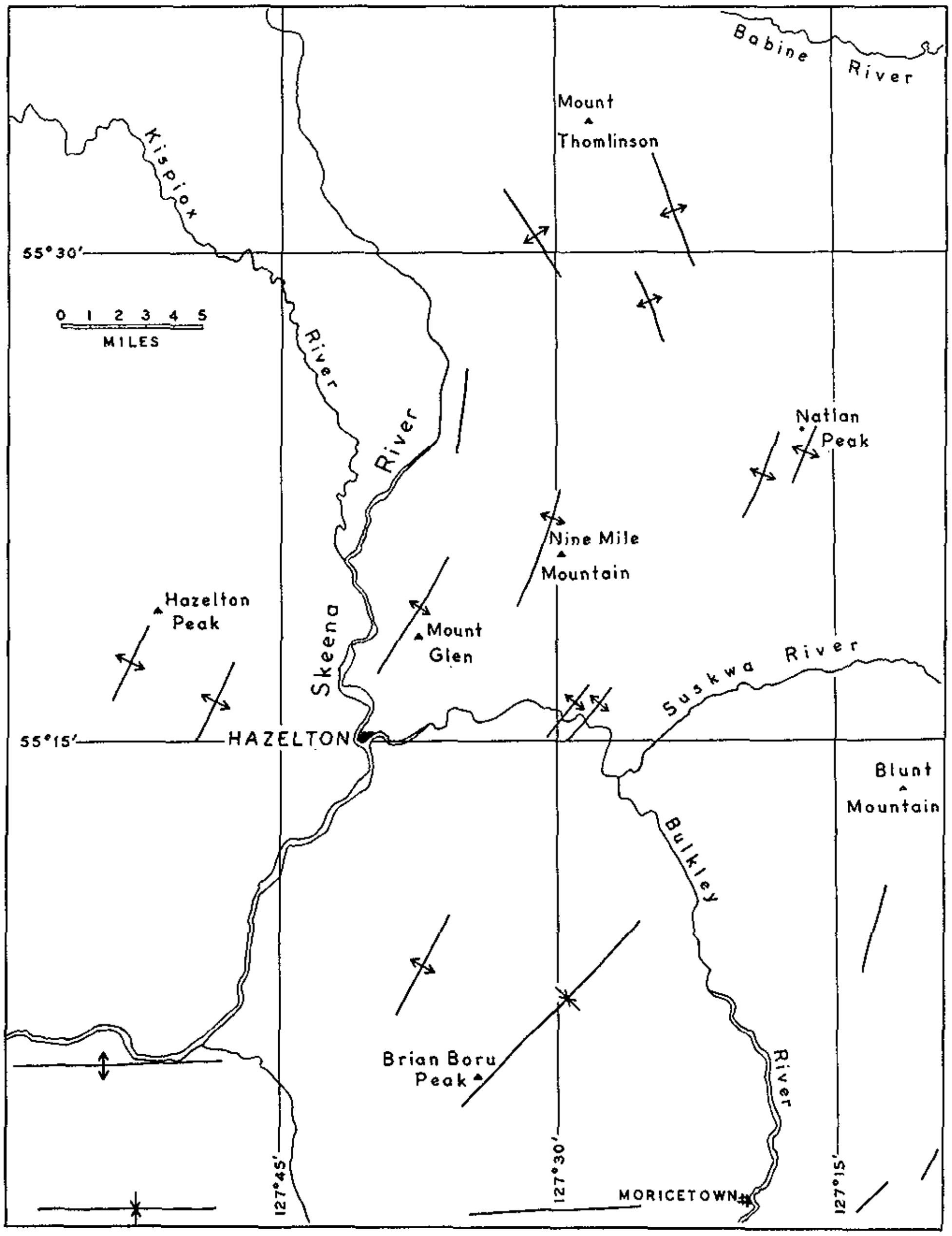


Figure 8. Fold axes and trend lines of the Hazelton area showing regional swing.

elongated north 25 degrees west and consists of two domes connected by a saddle. It cuts the northeastern limb of the major syncline obliquely. The only internal structure consists of an orthogonal system of joints parallel and normal to the contact. Details of the structure of the stock are treated with the petrology on pages 31 to 33, and the shape is shown in an isometric sketch, Figure 4.

FAULTS

Faults are conspicuous in the Rocher Deboule Range (*see* Plate I), and it seems certain that large faults isolate the range from neighbouring mountain masses. Within the range three large, northerly trending faults, the Cap, Chicago Creek, and Pangea faults, cut the area into four separate fault blocks which for discussion have been called the western, west central, east central, and eastern fault blocks. In addition to the major faults there are related minor faults and a few apparently unrelated faults of earlier age.

The Mill fault is parallel to Red Rose Creek and appears older than the northerly system of faulting. The fault is nowhere exposed but plainly separates areas of dissimilar structure in the Red Rose formation. Its movement is uncertain, but probably involves wrenching. If a similar fault is present south of Brian Boru Creek it would explain an apparent pinch-out of stratigraphic units. The Mill fault appears to be cut by the Chicago Creek fault and to continue on the north side of Tiltusha Peak.

The northerly faults are all subparallel, trending about north 10 degrees west. They are from west to east, the Cap fault, the Chicago Creek fault, and the Pangea fault. The Cap and Pangea faults are shown on Map 44-24, with courses somewhat different to those on Figure 2 of this bulletin. All faults can be traced at least 10 miles.

The Cap fault is not seen but is closely defined in the valley of the southernmost tributary of Brian Boru Creek and in the vicinity of the trail from the Cap property to the Victoria mine (Hazelton View). The fault seemingly dips westward and is a normal fault. Rock sequences of the western fault block so closely resemble those of the central and eastern fault blocks that it has been assumed they are correlative. If such is the case the western block is downthrown relative to the west central block. The trace of the fault on steep slopes indicates a westerly dip of about 50 to 70 degrees. The amount of dip-slip is large, 5,000 to 10,000 feet.

The Chicago Creek fault is seen in the bed of the northern tributary of Chicago Creek and on the ridge between Juniper and Armagosa Creeks and is closely defined from the west face of Brian Boru Peak to Tiltusha Peak and also near the Red Rose mine. The fault dips westward at 70 degrees and has a normal movement of about 2,000 to 3,000 feet, judging by the separation of member D of the Red Rose formation. Where the fault cuts the stock the movement may be less. The Red Rose vein shear (*see* Red Rose mine, pp. 56–59) appears to be a related minor fault with a small (300 to 400 feet) movement in the same sense.

The Pangea fault is not as well known as the other two faults. For much of its course it separates parts of the Brian Boru formation that cannot be distinguished. A shear on the ridge south of Corya Creek is most probably its southern continuation. Elsewhere it was not observed, but it is closely defined on the ridge between Porphyry and Mudflat Creeks and the spur northwest of Mudflat Creek. The east block has moved down relative to the east central block an undetermined amount, but certainly several thousand feet. It appears to be most probably a steep, easterly dipping normal fault, although the shear south of Corya Creek dips 70 degrees westward.

On the spurs east of Tiltusha and Red Rose Peaks northerly trending faults isolate small roof pendants from adjacent pre-granodiorite rocks. These may be parts of the same fault which would seem to have a movement of only a few hundred feet with the east side moving down.

The net effect of the three large northerly faults is that the central blocks, particularly the east central block, are raised as a horst. The central fault blocks contain the Rocher Deboule stock which is oriented essentially parallel to the faults. Judging by topography the faults play out just south of where they are mapped. The faults are younger than the stock, at least in part. These facts and the similarity of orientation of faults and stock lead to speculation that the features might be related. Possibly the faults result from continued upward movement of the stock after solidification of the domes, but more likely, the orientation of the stock may simply have influenced the direction of failure resulting from other forces.

Armstrong (1944b, Map 44-24) shows faults in the valleys of the Bulkley, Skeena, and Kitseguecla Rivers. The areal geology predicates the existence of a large fault in the Bulkley Valley that has dropped the eastern block of the Rocher Deboule Range many thousands of feet relative to the block of Blunt Mountain. Field evidence indicates a fault northeast of Beament station and near the mouth of Porphyry Creek. The Moricetown flows may have erupted from a linear vent along the west side of the valley, because cuestas of basalt dip gently eastward from Doughty station to Corya Creek and a line of basaltic dykes continues northward from Corya Creek to Straw Creek. There has been some disruption of the Moricetown formation by faulting.

Less is known of faults in the Skeena and Kitseguecla Valleys. The western part of the map-area contains a normal sequence of Hazelton rocks in simple open folds and gentle attitudes. Beyond the map-area, Map 44-24 shows similar rocks contorted in small compressed folds trending obliquely to those of the Rocher Deboule Range. Hence faulting in major valleys is probable.

The Rocher Deboule Range is isolated by these wide valleys which together form an ellipse some 20 miles by 16 miles in major and minor axes. Maps 44-23 and 44-24 indicate that these valleys contain a system of faults that approaches a complete ellipse and where faults are not indicated there is deep drift. Hence a complete elliptical fault system may isolate the range from adjacent mountains. The rocks of Rocher Deboule have been dropped relative to those of the neighbouring mountains preserving the youngest Hazelton division, the Brian Boru formation. These massive flows and breccias occur nowhere else except in minor amount on Hudson Bay Mountain. Consideration of these facts leads to the speculation that the essential structure of the range may be a large caldera or volcano-tectonic depression. However, it must be admitted that the known facts are as readily explained by a graben structure.

THE AGE OF STRUCTURES

The known sequence of events took place within a minimum of geological time. Deposition of the Red Rose formation began in the last part of the Jurassic and continued presumably until the end of the Aptian stage of the Lower Cretaceous (Lower Blairmore) during which time more than 8,000 feet of sediments were deposited. This deposition was followed conformably by at least 5,000 feet of volcanic flows of presumably Albian age or even younger. Thereafter the Rocher Deboule stock was emplaced, major faulting took place, the range was probably uplifted, and the Bulkley Valley was created, all prior to deposition of the Moricetown formation of Upper Cretaceous or Paleocene age. Most of these events occurred in the early Upper Cretaceous.

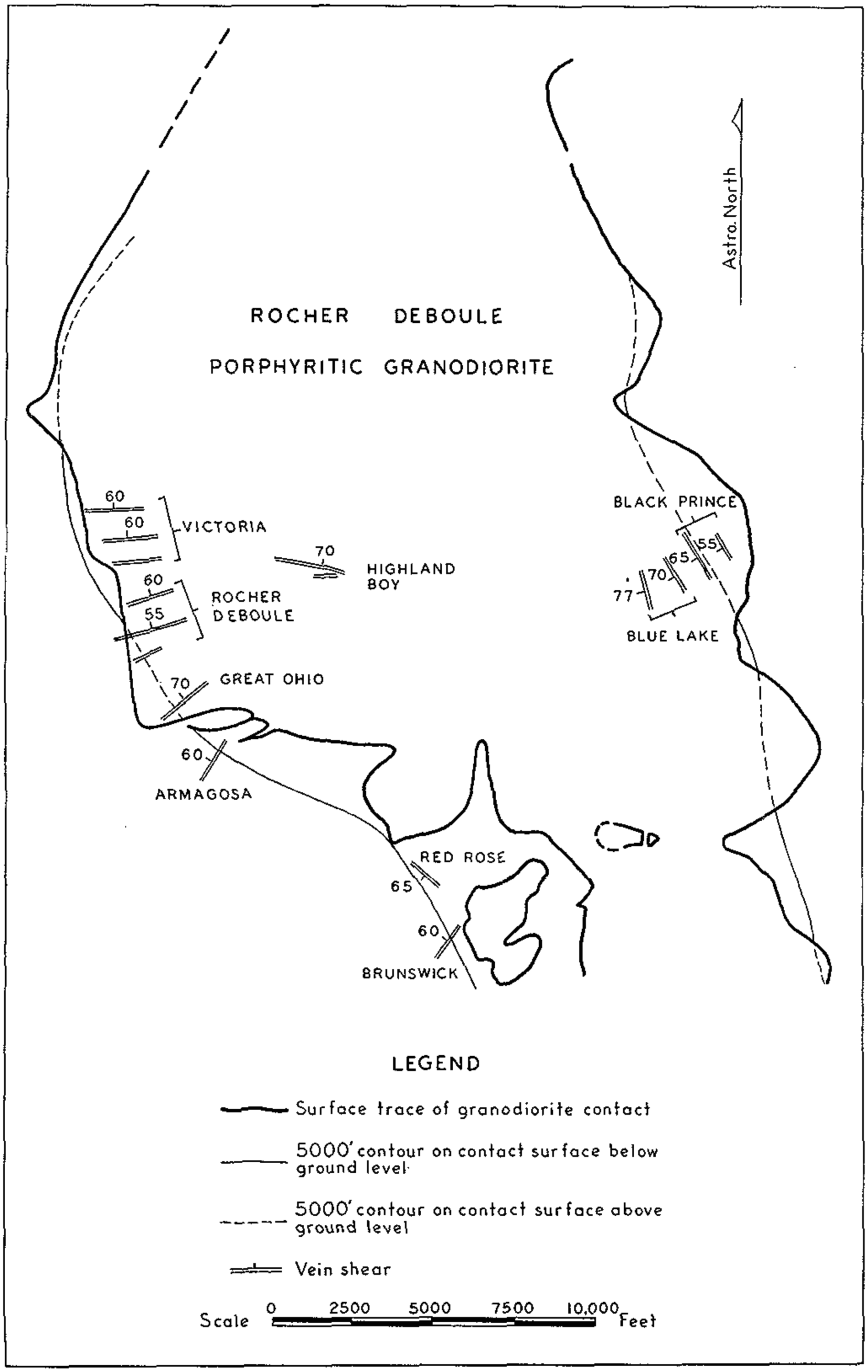


Figure 9. Distribution and orientation of vein shears of the northern dome.

CHAPTER IV.—MINERAL DEPOSITS

GENERAL DISCUSSION

History

The Rocher Deboule Range has produced ores worth about eight million dollars, chiefly tungsten* and copper ores, but with values from gold, silver, arsenic, cobalt, molybdenum, lead, and zinc. Prospecting was sporadic prior to 1910, but in that year it became very active with the result that most of the major properties were soon discovered. Development was generally slow until the completion of the railway in 1915 and the coming of high copper prices in the latter part of the Great War. With the sharp drop in prices following 1919 all mining activity in the area languished, with only a minor flurry about 1929 until World War II. When the Asian sources of tungsten were reduced in 1941/42 the demand eventually led to the Red Rose tungsten mine being brought into production. After the war activity again lapsed until 1950–54 when the first widespread search for uranium started. At about the same time copper prices rose and demand for tungsten was renewed when Asian supplies were again curtailed because of the Korean war; this led to prospecting, development, and production of tungsten and copper concentrates. The increasing availability of tungsten in 1954 brought increasing stringency of requirements by the General Services Administration of the United States government, the chief buyer of concentrates, and led to the closure of the Red Rose mine in December, 1954. This was the end of the most recent activity in the range.

Distribution

Known mineral showings in the Rocher Deboule Range are concentrated peripherally about the stock and particularly around the northern dome of porphyritic granodiorite. The major deposits and most of the minor ones are all within a few thousand feet of the contact of the northern dome and chiefly lie within the stock (*see* Fig. 9). For example, the Rocher Deboule and Victoria mines are just within the contact and the Red Rose mine just without. Only one small deposit (Daley West) has been found in the fine-grained quartz monzonite, only one (Sultana) within the southern dome of the porphyritic granodiorite, and only a few are more than half a mile from the stock (Cap, Golden Wonder, Three Hills, and Brian Boru). It can therefore be concluded that the deposits of the Rocher Deboule Range are related in some way to the northern dome of the porphyritic granodiorite phase of the Rocher Deboule stock.

All the known deposits are veins filling minor shears, or, less commonly, tension fractures. The main group of veins, those in or close to the northern dome, are all related geometrically, in structural history, and in sequence and type of mineralization. These veins occur as discrete bodies within fairly continuous shears of minor movement that follow joints related to the cooling history of the stock. Formation of the veins took place in three stages and involved three types of mineralization. The mineralogy of the main stage varies systematically with distance from the contact.

Veins beyond the periphery of the stock are fairly similar structurally and mineralogically to those in and near the stock, but with two significant differences. Most of them strike slightly north of east and dip steeply northward in minor shears rather than being oriented in a pattern related to the stock. They contain chalcopyrite as the most abundant valuable mineral with pyrite, pyrrhotite, arsenopyrite,

* Tungsten is called wolfram according to international agreement but usage in North America continues to favour tungsten.

and sphalerite, but no scheelite. In a general way they contain less gold, silver, cobalt, and nickel.

In addition to the vein deposits there is disseminated sulphide mineralization. This is almost entirely pyritic and is rarely intense, except near the southern contact of the southern dome where it contains traces of chalcopyrite. Zones several hundred feet wide near valley level occur on either side of the large recent moraine on Corya Creek and in some dykes higher up the slopes. It is not known what relationship, if any, this type of mineralization has with the vein mineralization of the northern dome nor with that of the Sultana vein of the southern dome.

Veins of the Northern Dome

Veins of the northern dome are the best known, and to date have proved the most valuable. The veins are all contained in minor shears which are arranged in a pattern related to the orthogonal joint system of the stock (*see* Figs. 4 and 9 and p. 33). This system involves three sets of fairly continuous joints ideally at right angles to one another: one set parallel to the contact, a second set striking normal to the contact and radial, and a third set dipping normal to the contact and intersecting it horizontally. The joints are believed to have resulted from cooling contraction of the stock and adjacent wallrock. Adjustments during late minor shearing have followed the joint planes, as for example, easterly trending minor shears beyond the stock preferentially follow radial joints where these strike nearly in this direction. Over-all shear orientations may be 10 or even 20 degrees different from the joint orientation, but generally have the same strike. A shear will follow an individual joint for some distance and then cut across to the next parallel joint. The radial arrangement of the shears in the southwestern margin of the northern dome is very clear in Figure 9 from the Victoria to the Armagosa. The Armagosa veins are outside the stock but are part of the same system. Joints of a different set are utilized on the eastern margin of the dome: those that are normal to the contact surface and have a horizontal trace on it. These can be seen to roll over from a dip of 77 degrees west at the western vein of the Blue Lake property to 55 degrees west at the eastern vein of the Black Prince. The Red Rose vein parallels the contact and the Brunswick fits the same set as the Rocher Deboule veins, but both veins are just outside the stock and there is no assurance that other factors are not more important, for instance, the Red Rose shear may be closely related to the Chicago Creek fault.

Mineralization

All the veins of the northern dome show a similar mineralogy and sequence of deposition. Three stages of mineralization are evident in the veins which have been well studied, and are indicated in other veins.

The first, a pegmatitic stage of mineralization, formed very soon after the cooling joints opened and probably when the mild shearing forces were initiated. Veins formed at this stage were composed predominantly of black hornblende and glassy quartz with feldspar, apatite, magnetite, scheelite, tourmaline, ferberite, molybdenite, and possibly uraninite. The Rocher Deboule and Victoria veins have this stage well developed and the Red Rose and Black Prince veins consist predominantly of this stage.

The second stage seems quite closely associated with the first, although it is clearly later. It forms the main sulphide mineralization: chalcopyrite, arsenopyrite, pyrrhotite, pyrite, and cobalt-nickel sulpharsenides. These minerals replace the hornblende, probably replace the quartz and other minerals, and fill cavities. The main orebodies of the Rocher Deboule veins are composed predominantly of minerals of this stage plus remnants of the first stage. Within veins which contain mineralization of this stage and transect the contact there is commonly a zoning in which chalcopyrite, pyrrhotite, and arsenopyrite within the stock grade to cobalt-nickel sulpharsenides at the contact. Much of the precious metal content of veins was deposited at or during the second stage, probably predominantly within the cobalt-nickel sulpharsenides.

The third stage is quite separate from the others and veins formed during it cut through the earlier veins as distinct entities. Mineralization of the third stage consists dominantly of milky quartz, commonly banded or with comb structure, together with sphalerite, tetrahedrite, galena, pyrite, and some chalcopyrite and siderite and calcite. Some precious metals are present, principally silver in tetrahedrite. The third stage is evident in much of No. 2 vein of the Rocher Deboule mine, especially on the 1200 drift, and is the principal mineralization of the Brunswick vein. Some minor tension veins are filled only with this type of mineralization.

Minerals of the three stages were deposited at successively lower temperatures from pegmatitic to mesothermal. Also, in veins containing the second stage, zoning of chalcopyrite, pyrrhotite, and arsenopyrite within the stock to cobalt sulpharsenides near the contact possibly indicates decreasing temperature of deposition in that direction. The three stages overlap in space and if mineral zoning within the second stage indicates a marked thermal gradient then the stages were probably compressed in time.

Genesis

The first stage of mineralization, the pegmatitic stage, is directly linked to the late consolidation stage of the porphyritic granodiorite. The second stage, because its distribution is seemingly identical with that of the first stage and because it is spatially related to the stock, would also seem clearly to be related to the Rocher Deboule stock. The third stage is perhaps more widespread, and although nothing indicates that it is directly related to the stock there is nothing to show that it is not, particularly as it completes a sequence of mineralization from high to low temperature. The veins of the northern dome probably owe their origin to the porphyritic granodiorite and their distribution to factors resulting from the cooling history of the stock, including the evolution of the joint system, minor shearing forces, and thermal control of deposition.

Kindle (1954, p. 18) from regional considerations points out that veins associated with individual stocks in the region contain distinctive mineral deposits. It is interesting to note that all the deposits of the northern dome contain a distinctive mineral suite that is present nowhere else in the region. They all contain small amounts of uraninite, ferberite, scheelite, and small to large amounts of cobalt-nickel sulpharsenides. This consanguinity suggests a common origin.

DESCRIPTIONS OF PROPERTIES

Descriptions are arranged in alphabetical order. They are numbered from north to south, first on the west side of the stock and then on the east. The numbers show on the areal map, Figure 2.

Armagosa (8)

This property is on the southeastern part of the ridge between Juniper and Armagosa Creeks and adjoins the Great Ohio on the south. The property was originally part of the Great Ohio group, but has been relocated many times since. At one stage it was called the Spaulding group. It was last prospected intensively by Skeena Silver Mines Ltd. in 1952. No claims are held at present (December 31st, 1958).

The property is chiefly underlain by hornfelsic greywacke and argillite of members A and B of the Red Rose formation, cut by feldspar porphyry and a few granodiorite dykes. The contact of the north dome of Rocher Deboule granodiorite borders the property on the north along the ridge top. The sedimentary rocks chiefly strike about north 30 degrees west and dip about 30 degrees to the northeast. The property is crossed by a number of small shears that trend northeast and dip steeply to the east—these are vein-filled in part. The most prominent shear of the group is not well mineralized, but forms a marked gully on the hillside and also the lower part of Armagosa Creek.

Old workings are at about 4,350 to 4,800 feet elevation, about 3,000 feet east of the Juniper Creek road. There are two adits and one small shaft. The lower adit at 4,340 feet elevation is caved at the portal; the upper one, at 4,618 feet, is 150 feet long and crosscuts northerly to a shear trending north 31 degrees east. It contains a few stringers of chalcopyrite and magnetite. There is an old shaft at 4,800 feet.

Work in 1952 was concentrated on a zone of veins lying northwest of the old showings about half way between these and the Great Ohio. They are largely parallel to and west of the gully-forming shear previously mentioned and are exposed from about 4,800 feet to 5,800 feet elevation. They strike north 30 degrees east and dip 60 degrees to the west. The veins are chiefly small, 1 foot or less, but contain abundant scheelite in places.

[References: E. D. Kindle, 1954, p. 77; *Minister of Mines, B.C.*, Ann. Rept., 1912, p. 114.]

Black Prince (13)

This property is near the head of Mudflat Creek, 6 miles by good trail from a point on Highway No. 16, 5½ miles east of New Hazelton. The showings are between 4,200 and 5,400 feet elevation on a northerly spur of the ridge between Mudflat and Porphyry Creeks (*see* Fig. 9).

The property is owned by Mrs. Barbara S. Sargent of New Hazelton and consists of recorded claims, whose names and numbers have varied in the past. In December, 1958, there were three claims, the Eriksen, Eriksen No. 1, and Eriksen No. 2.

The property was first located in 1911 or 1912 and was first described in some detail by J. D. Galloway (1916, pp. 117, 118). Much of the exploratory work was done during this early period, the remaining work having been done in 1944/45 and 1951–53.

The showings are in porphyritic granodiorite of the Rocher Deboule stock, 2,500 feet west of the eastern flank of the north dome. The granodiorite is intensely jointed in the orthogonal pattern (*see* pp. 33 and 46). In the vicinity of the property the joints parallel to the contact surface and the cross-joints normal to them are most prominent. The latter particularly constitute planes of weakness along which dykes, shears, and veins have formed. They strike north 30 degrees west and dip 70 degrees to the southwest in the western part of the property and flatten to a dip of 55 degrees on the eastern part.

The showings consist of one main shear zone and a few smaller subparallel ones. The main shear is on the north face of a spur that towers above the tarn lakes at the head of Mudflat Creek. The shear zone can be traced with some gaps for about 1,000 feet horizontally and about 700 feet vertically. The shear strikes north 30 degrees west and dips 65 degrees to the southwest. Over much of its trace it consists of two strands separated by 4 to 8 feet of variably sheared wallrock and with variable amount of quartz vein-filling and replacement mineralization. Generally the hangingwall shear is the better mineralized. Minor shears splay off the main one, near the bottom into the footwall and near the top into the hangingwall.

The shear first becomes exposed at about 4,550 feet elevation where there are a number of subsidiary strands. Here it is essentially barren of quartz, but at about 4,700 feet one of the tributary shears consists of a sheeted zone containing pods of quartz with some pyrite and scheelite. The main shear is largely barren until about 4,890 feet elevation where the sheeted zone is 12 feet wide with veins in hangingwall and footwall and some mineralized wallrocks. Drusy vein matter consists of quartz crystals with some 1-inch-long tabular ferberite crystals, pyrite, tourmaline, and molybdenite. A 42-foot-long adit at 4,925 feet elevation exposes a well-defined hangingwall shear with the same mineralization plus chalcopyrite across 2 feet of sheared and mineralized wallrocks. Above the adit the vein and shear are 4 to 8 feet wide and are highly weathered and leached, but show indications of similar mineralization. The vein is exposed in several open cuts. At 5,000 feet a 20-foot long adit shows 2 feet of sheared and leached vein quartz. A bench is reached at 5,020 feet and here the vein is exposed in a series of open cuts for 120 feet. At the southern end adjacent to the steep slope open cuts expose a vein originally composed dominantly of pyrite which is now mostly leached, leaving a delicate box work of quartz. Some ferberite is evident. In the last 30 feet the shear seen in the cuts is not very well developed, but it may have branched into the hangingwall. The bench is drift covered for the next 400 feet, but beyond, on a second steep bluff, two parallel shears occur which seem to represent the same zone. About 6 inches of highly leached vein matter occurs in these shears. On top of the bluff the zone appears to dissipate.

Samples were taken at: (1) The face of the lower adit (4,925 feet), (2) on the vein at 4,975 feet, and (3) on the bench at 5,020 feet, 55 feet south from the break in slope. These assayed as follows:

Sample No.	Width in Feet	Au	Ag	Cu	WO_3	Mo
1	2	trace	0.2	0.36	0.82	0.100
2	4	0.01	0.3	0.043	0.84	0.062
3	3	0.01	0.2	0.029	0.30	0.088

A parallel vein is exposed 800 feet east of the main vein in an adit at 4,300 feet elevation. This is contained in a shear striking north 30 degrees west and dipping 55 degrees to the southwest. The adit is a drift 112 feet long, trending north 28 degrees west. The vein is not more than 6 inches wide, but in three places there are gash veins branching into the hangingwall that contain 4 to 6 inches of solid chalcopyrite. Scheelite is also present. The vein is traced by open cuts about 50 feet down the slope, but is not very evident above or at the face of the adit.

[References: E. D. Kindle, 1954, pp. 30–32; J. J. O'Neill, 1919, p. 25; J. S. Stevenson, 1943, pp. 67–71; *Minister of Mines, B.C.*, Ann. Repts., 1913, p. 107; 1916, pp. 117, 118; 1918, pp. 113, 114.]

Blue Lake (14)

This property is immediately west of the Black Prince property at the head of Mudflat Creek and is reached by the same trail up the creek. The property has commonly been part of the Black Prince, but latterly has been held separately. On December 31st, 1958, it was held by Louis A. Parent of New Hazelton as the recorded claims Moly B No. 1 and No. 2. Much of the original prospecting was done by O. L. Skogland of Zeballos.

The property is entirely within the Rocher Deboule porphyritic granodiorite near the southwestern part of the north dome, but a few large rafts of hornfelsic argillites are exposed.

The showings consist of a number of veins on both sides of the cirque immediately west of the Black Prince showings, between 5,300 and 6,000 feet elevation. On the east side of the cirque a vein can be traced up the rim for 150 feet vertically and intermittently for a few hundred feet to the south on the ridge. It ranges from a few inches to 2 feet wide within a wider shear zone. The zone strikes north 30 degrees west and dips 70 degrees to the west, subparallel to the Black Prince shear. The quartz vein contains chalcopyrite, pyrite, molybdenite, tetrahedrite, molybdite, and some scheelite. It shows a banded structure throughout and locally a comb structure. Near this vein to the east, and possibly a branch of it, is a small vein that strikes north 75 degrees west and dips 65 degrees to the north. It consists of milky white quartz with some tetrahedrite and chalcopyrite.

Another main vein occurs at about 5,800 feet elevation on the precipitous western slope of the cirque, some 2,000 feet northwest of the other veins described. It strikes north 15 degrees west and dips 75 to 80 degrees to the west. The shear zone contains 1 foot or so of rusty weathered quartz vein in a wider zone of sheared granodiorite with a parallel basic dyke. The vein contains scheelite, molybdenite, and some chalcopyrite with traces of ferberite in a gangue of quartz and hornblende and rare tourmaline. The vein contains some drusy openings. Near this vein are others with the same orientation. Some oblique, smaller veins strike north 60 degrees east, dip close to vertically, and contain tetrahedrite as the main mineral.

[Reference: E. D. Kindle, 1954, pp. 32–34.]

Brian Boru (11)

This property is near the head of the south branch of Brian Boru Creek, west of Brian Boru Peak. It is reached by a trail 4 miles long that follows Brian Boru Creek from the confluence with Juniper Creek, 5 miles by road east of Skeena Crossing. The property consists of two Crown-granted claims, the Brian Boru No. 1 (L. 607) and Brian Boru No. 2 (L. 608). The property was located probably in 1914 or 1915 and Crown-granted in 1917 by John Craegh, who was a part owner until his death a few years ago. J. C. T. Arenseneau and Martha McKinley are the other owners. Little work has been done since the late 1920's.

The showings are on the west end of a ridge that extends westward from Brian Boru Peak. They are all near the contact of the Red Rose and Brian Boru formations that here strike northward and dip about 15 degrees eastward. Between 5,000 feet and 5,450 feet elevation a number of small veins are exposed in pits, trenches, and small adits. Individual workings are described by Galloway (Ann. Rept., 1914, pp. 192–193) and by Kindle (1954, pp. 34–35). The veins are chiefly 30 to 60 feet long and 3 to 12 inches wide; they strike northeastward and dip 45 to 65 degrees northwestward. They consist almost entirely of black sphalerite with some pyrite, pyrrhotite, galena, chalcopyrite, and quartz. They apparently contain little gold or silver.

[References: E. D. Kindle, 1954, pp. 34, 35; *Minister of Mines, B.C.*, Ann. Repts., 1914, pp. 191–193; 1926, p. 127; J. J. O'Neill, 1919, pp. 19, 20.]

Brunswick (10)

This property extends along Red Rose Creek, south of the Red Rose property. The workings on the main vein are 3,600 feet northeast of the Red Rose mill at about 4,600 feet elevation. The property consisted originally of the Brunswick and Kaslo claims located by J. Miller in 1912 and held by him until his death in 1940. Claims were relocated in 1951 by Skeena Silver Mines Ltd., which was formed to explore the Brunswick property. Of the claims then located the following were in good standing on December 31st, 1958: Brunswick Nos. 1, 2, 3, 4, 6, 7, 9, and 10, Brunswick Fraction, and Betty No. 9.

The showings are underlain by hornfelsic argillites of member B of the Red Rose formation containing a number of dykes of feldspar porphyry and diorite, and are about half a mile from the Rocher Deboule granodiorite on Red Rose Creek.

The main vein is within a shear and is explored by two adits. The lower one (4,540 feet elevation) is 200 feet long and follows the vein which strikes about north 40 degrees east and dips 45 to 75 degrees northwest. The first 75 feet of the adit is timbered and lagged. Beyond this to 125 feet there is a vein lode 3 to 4 feet wide consisting of quartz, silicified wallrock, and minor sulphide minerals, chiefly sphalerite and galena. A sample taken 90 feet from the portal across 3 feet assayed: Gold, trace; silver, 2.2 oz. per ton; copper, 0.1 per cent. The last 75 feet follows a shear containg 1 foot of gouge and shattered wallrock and only a minor amount of quartz or metallic mineralization. The wallrocks are chiefly hornfelsic argillite, but are in some places bleached and in others intensely biotitized. The upper adit (4,630 feet elevation) was caved at the portal in 1954. It reportedly (Kindle, 1954, p. 35) is 90 feet long with a quartz vein, 6 inches to 2 feet wide, well mineralized with galena, sphalerite, tetrahedrite, and some chalcopyrite. About 7 tons of ore in a dump at the portal was estimated by Kindle to contain 10 per cent sulphides and relatively high silver.

Skeena Silver Mines Ltd. in 1952 put down four short diamond-drill holes to explore the continuation of the vein which was reportedly displaced by a fault in the upper adit (Ann. Rept., 1952, p. 93). Another longer drill hole was collared at 5,065 feet elevation to explore a possible intersection of the Red Rose shear with the Brunswick.

[References: E. D. Kindle, 1954, pp. 35, 36; *Minister of Mines, B.C.*, Ann. Repts., 1914, p. 191; 1925, pp. 134, 135; 1952, p. 93.]

Cap (3)

This property is 5 miles south of South Hazelton, on the lower slopes of the northwestern face of the Rocher Deboule Range at about 2,200 feet elevation. It is reached by a good trail to the Victoria mine from the Comeau farm on Highway No. 16. The showings were investigated chiefly between 1914 and 1918 and some further work was done in the late 1920's. Ground has been held in the past by located claims. In 1917 a shipment of 29 tons of sorted ore yielded: Gold, 3 oz.; silver, 252 oz.; copper, 3,376 lb.

The property is underlain by porphyritic flow rocks and breccias of the Brian Boru formation which strike northward and dip gently eastward. These porphyries contain more pyrite than is normal and are inclined to be rusty weathering. The large northerly striking Cap fault (*see* Fig. 2) passes about 2,000 feet east of the showings.

The showings consist of a main vein, a subsidiary vein, and a few stringers. Most of the workings are on the main vein and consist of a 75-foot adit crosscut leading to a 95-foot drift which connects with a shaft that extends 20 feet below the drift. The adit is caved at the portal. Another small shaft is 200 feet southwest of the first and a 200-foot adit is a further 400 feet southwest. There are, in addition, a number of open cuts.

The vein shear strikes north 70 degrees east and dips 70 degrees or more to the north. It is silicified and in places contains vein quartz with pyrite, siderite, chalcopyrite, and some arsenopyrite. In the vicinity of the main shaft the vein shear contains an ore shoot from which the ore shipment was made.

The subsidiary vein is several hundred feet east of the last workings on the main vein. It strikes nearly east and dips steeply north. It is exposed by some open cuts in one of which it is about 3 feet wide and contains pyrite, sphalerite, and chalcopyrite.

[References: E. D. Kindle, 1954, pp. 36, 37; *Minister of Mines, B.C.,* Ann. Repts., 1914, p. 200; 1916, pp. 115, 116; 1929, p. 155; J. J. O'Neill, 1919, pp. 23, 24.]

Daley West (12)

This property is 2 miles south of New Hazelton on the east side of Mission (Station) Creek at 2,000 to 2,400 feet elevation. It is reached by a good short trail from the end of logging roads at the foot of the mountain on Mission Creek. The property has been held by located claims. No work appears to have been done on the showings since the original investigations of 1916.

The showings are within the fine-grained quartz monzonite phase of the Rocher Deboule stock. The workings consist of two adits, one now caved at the portal, and some open cuts on a talus-covered and wooded slope. The workings expose a silicified shear zone with small amounts of vein quartz that strikes north 20 degrees east and dips 65 degrees northwest. This shear zone contains some masses of arsenopyrite with pyrrhotite, pyrite, and some chalcopyrite. According to assays quoted by Galloway (Ann. Rept., 1916, p. 117) the arsenopyrite, unlike that of the Victoria and Rocher Deboule mines, does not carry cobalt or nickel and little gold and silver. Assays quoted by Kindle (1954, p. 40) show the vein to contain no tungsten or uranium.

[References: E. D. Kindle, 1954, pp. 39, 40; *Minister of Mines, B.C.,* Ann. Rept., 1916, p. 116; J. J. O'Neill, 1919, p. 25.]

Golden Wonder (2)

This property is on a large rock drumlin on the bench northwest of the Rocher Deboule Range. It is 4½ miles southwest of South Hazelton at about 1,300 feet elevation. It is one-half mile from Highway 16 near the road from the Comeau farm. The showings were first investigated about 1912, but not much work was done until 1917 and 1918. The property has been held by location and was relocated in the early 1950's. There were no valid claims at December 31st, 1958.

The showings are underlain by somewhat pyritic argillite of the Red Rose formation which is believed to be folded with a trend east of north.

Two shear zones are reported, with most of the workings on the southern one. The workings consist of a shaft 100 feet deep on top of the knoll, a shallower shaft a few hundred feet west, and a number of open cuts. The shear zone trends north 85 degrees west and dips 80 degrees north and has been traced more than 500 feet. It is up to 3 feet wide, is silicified in places, and contains small quartz stringers. In the shear are lenses of almost pure sulphides, mostly pyrrhotite, but including chalcopyrite, arsenopyrite, and pyrite. Kindle (1954, p. 44) reports assays from two ore piles near the main shaft as follows: Gold, 0.20 and 0.46 oz. per ton respectively; silver, 7.25 and 7.63 oz. per ton; copper, 6.50 and 4.69 per cent; nickel, none. Kindle also reports an assay of some sacked ore that shows 0.15 per cent tin.

At the north end of the rock drumlin, 1,000 feet northeast of the main shaft, a shear zone strikes north 70 degrees west, dips 75 degrees to the north, is up to 4 feet wide, and is exposed in a series of open cuts for several hundred feet. The shear is occupied by a post-mineral porphyry dyke. Small quartz stringers and lenses of sulphides, mostly pyrite and chalcopyrite, occur within the shear.

[References: E. D. Kindle, 1954, pp. 44, 45; *Minister of Mines, B.C.,* Ann. Rept., 1917, pp. 107, 108; J. J. O'Neill, 1919, p. 24.]

Great Ohio (7)

This property is on the western end of the ridge between Juniper and Armagosa Creeks. It adjoins the Rocher Deboule property on the north and the Armagosa (Spaulding) on the south. It was located in 1910 by Sargent and Munroe. It consists now of one Crown-granted claim, the Great Ohio (L. 702), but formerly consisted of many Crown-granted and located claims, some of which covered the property described here as Armagosa. The Great Ohio claim was acquired by Western Uranium Cobalt Mines Limited (now Farwest Mining Limited, *see* p. 60) in 1952, but no work was then done.

The property is chiefly underlain by porphyritic granodiorite of the northern dome of the Rocher Deboule stock, but hornfelsic Red Rose formation outcrops on the south of the claims and the contact has an east-west trace down the ridge to Juniper Creek.

The main vein shear is near the contact and strikes north 50 degrees east and dips 70 degrees to the northwest. The vein is exposed on very steep bluffs over 800 feet vertically, and is as wide as 4 feet. It contains scattered mineralization of galena and sphalerite, or of pyrrhotite, arsenopyrite, and chalcopyrite, but is everywhere intensely oxidized.

An adit at 4,300 feet elevation follows a subsidiary parallel shear for 355 feet northeast then crosscuts 260 feet to the southeast to follow the main shear for 400 feet northeast. Between the two shears another parallel stringer is followed by a drift for 130 feet. Much of each vein is composed of sheared granodiorite and the mineralization in each is sparse.

[References: E. D. Kindle, 1954, pp. 45, 46; *Minister of Mines, B.C.*, Ann. Repts., 1911, p. 80; 1914, pp. 188, 189; J. J. O'Neill, 1919, p. 18.]

Highland Boy (6)

This property is on upper Juniper Creek east of the Rocher Deboule mine. The showings extend along the top of a rugged ridge north of Juniper Creek which locally has been called Balmoral Peak. An old wagon road extends up Juniper Creek to the head of the valley below the eastern showings, about 1 mile east of the Rocher Deboule mill.

The property was located about 1910 and acquired in 1912 by the Rocher Deboule Copper Company Limited, who also owned the Rocher Deboule mine. It was leased by the Delta Copper Company of Edmonton in 1915, who did most of the exploration and who in 1917 made a shipment of about 75 tons which contained: Gold, 4 oz.; silver, 35 oz.; copper, 10,493 lb. The property has commonly been called the Delta Copper and was leased sporadically in the early 1920's. It was acquired in 1951 by Western Uranium Cobalt Mines Limited (now Farwest Mining Limited, *see* p. 60) who did no work on the property.

The property consists of nine Crown-granted claims: Coral Queen (L. 532), Lucky Jack (L. 603), Delta Fraction (L. 604), Balmoral Fraction (L. 620), Highland Boy (L. 1000), Golden Fleece (L. 1001), Balmoral (L. 1002), Happy Jack (L. 1003), and Zig Zag Fraction (L. 1005). It originally included the Silver Tip (L. 1004), a Crown-granted claim that has reverted.

The property is entirely within the northern dome of porphyritic granodiorite of the Rocher Deboule stock. The showings consist primarily of two continuous subparallel vein shears striking nearly east-west and dipping steeply north. These are reportedly continuations of vein shears on the Rocher Deboule property, and certainly are part of the same set. The Chicago Creek fault crosses the property on the eastern end and showings are not known east of it.

The main showings consist of two vein shears that trend eastward and dip steeply to the north. The southern or lower vein shear has been correlated with the shear containing No. 4 vein of the Rocher Deboule mine, but this is doubtful. It is only known at the eastern end of the property on the Golden Fleece claim, where it closely approaches the upper vein. It is explored at about 6,800 feet elevation by one adit now caved at the portal. The vein does not appear to be very well mineralized.

The upper or Highland Boy vein shear can be traced from the northeast corner of the Golden Fleece claim across the Zig Zag Fraction, Balmoral, Lucky Jack, and Delta Fraction. It is possibly the projection of the shear of No. 2 vein of the Victoria property. The well-defined shear is 1 to 6 feet wide and is largely composed of shattered wallrock, but with good widths of vein matter in many places. It is readily accessible only in the eastern part of the property where, on the Golden Fleece and Zig Zag Fraction, it is exposed in a number of open cuts and two adits, one of which is caved. The main adit at 6,250 feet is open, is 300 feet long, and follows the vein which strikes north 67 degrees west and dips 70 degrees north. At the portal the vein is a stringer lode 2½ feet wide moderately well mineralized with chalcopyrite, pyrite, specular hematite, and magnetite. Elsewhere in the adit it varies between a tight barren shear in a lamprophyre dyke and a solid well-mineralized vein 18 inches wide. The gangue includes quartz, hornblende, and altered and replaced granodiorite. Ore minerals, besides the prominent ones just mentioned, include scheelite, uraninite, and a tin mineral. An assay quoted by Kindle (1954, p. 48) shows 0.90 per cent tin in one sample and O'Neill (1919, p. 17) indicates a tin mineral which is not identified. The ore shipped in 1917 was mined in this adit, from a stope and winze about 100 feet from the portal.

An adit on the Delta Fraction claim at the western end of the ridge is driven eastward for several hundred feet, but is south of the vein shear and nowhere cuts it.

[References: E. D. Kindle, 1954, pp. 47–49; *Minister of Mines, B.C.*, Ann. Repts., 1912, p. 114; 1914, pp. 189, 190; 1916, pp. 109–113; 1917, pp. 102, 103; 1918, p. 113; 1921, p. 97; J. J. O'Neill, 1919, pp. 14–18.]

Lone Star (15)

This property is on Pangea Creek which flows north into Mudflat Creek. The showings are at about 4,500 feet elevation on the west bank of the creek. They are reached by a branch trail from the Mudflat Creek trail to the Black Prince. The property has been held by recorded claims. The showings consist of slightly pyritiferous argillite of member B of the Red Rose formation cut by a few narrow pyrrhotite veinlets. These are prospected on the west bank of the creek by three small adits of which all but one 15-foot adit are caved at the portal. The showings are very close to the Pangea fault.

[Reference: E. D. Kindle, 1954, pp. 52, 53.]

Red Rose (9)

The Red Rose mine is on the ridge between Armagosa and Red Rose Creeks, both of which are tributaries of Juniper Creek (*see* Plate I). The mill camp (elevation about 4,000 feet) is on Red Rose Creek, 11 miles by road from Skeena Crossing. The road is currently (1958) blocked by slides 5 miles from Skeena Crossing. The mine camp is approximately 1 mile northeast of and 1,600 feet higher than the mill camp and is connected with it by switchback jeep road and aerial tramway (*see* Plates XI and XII). The property consists of fifteen Crown-granted claims and fractional claims: Tungsten No. 1 (L. 6250), Tungsten No. 2 (L. 6251), Tungsten No. 3 (L. 3041), Tungsten No. 4 (L. 3042), Tungsten No. 5 (L. 3043), Tungsten No. 6 (L. 3044), Tungsten No. 7 (L. 6252), Tungsten No. 8

(L. 6253), Wolframite Fraction (L. 3045), Tat Fraction (L. 6058), Eta Fraction (L. 6059), Scheelite (L. 6254), Gordie (L. 6255), Dee (L. 6256), and Jay (L. 6257). It is owned by The Consolidated Mining and Smelting Company of Canada, Limited.

History

The Red Rose was discovered in 1912 by C. Peterson and C. Ek. During the next seven years the property was vigorously prospected, attention being directed chiefly to the Red Rose shear on the south slope where some encouraging assays in gold, silver, and copper were obtained. Four small adits were driven between elevations of 5,150 and 5,696 feet. Only minor attention was paid to the large quartz vein which occurred in the shear at the top of the ridge and in which tungsten-bearing minerals were found in 1923. In 1939 The Consolidated Mining and Smelting Company of Canada, Limited, optioned the claims from Mrs. B. Sargent, of New Hazelton, and the following summer started a drilling programme on the quartz vein. The vein was subsequently developed by adits from the western slope and a 75-tons-per-day mill was built on Red Rose Creek. The mill was in operation from early in 1942 until November, 1943. The property was then inactive until 1951, when Western Uranium Cobalt Mines Limited (now Farwest Mining Limited, *see* p. 60) leased the property from the Consolidated company. A new mill was built which started operating at the end of the year. In the mine the 800 adit level was driven to the vein, and later an inclined shaft was sunk in the vein to the 1100 level. Mill capacity was increased to 140 tons per day. On December 15th, 1954, the mine was shut down because, according to the management, difficulty was experienced in producing concentrate satisfactory to the General Services Administration of the United States government to which the output was contracted. Most of the equipment was subsequently sold.

Production

Production from 1942 to the end of 1954 was as follows:—

Year	Tons	Gold	Silver	Copper	WO_3	
					Conc.	Units
		Oz.	Oz.	Lb.	Tons	
1942	8,066	......	......	....	132	8,760
1943	17,884	......	......	....	469	25,303
1952	21,137	......	......	....	276	20,359
1953	37,446	291	462	21,285	377	30,871
1954	29,642	272	361	38,423	444	25,252
Totals	114,175	563	823	59,708	1,698	110,545

In 1954 the mill heads averaged 1.43 per cent WO_3 and the tails 0.48 per cent WO_3.

Workings

The mine has twelve levels and sublevels, and most of the workings are in the plane of the vein. The level interval is not constant, but between the lower four levels it is 87 feet (100 feet in the plane of the vein). Access is provided by four adits—the 800 (elevation 5,659 feet), 600 (5,920 feet), 300 (6,133 feet), and 200 (6,237 feet) levels. The 600 level is the main haulage, and from it the ore is transported to the mill by aerial tram. From this level an inclined shaft extends in the vein to the lowest level (1100). The four old adits on the Red Rose shear on the south slope are caved at the portals.

Geology

The Red Rose mine is in the hornfelsic aureole surrounding the porphyritic granodiorite of the Rocher Deboule stock, it is in the western part of the saddle near the north dome (*see* Fig. 9), and is close to the contact (*see* Figs. 10 and 11), the 800 drift being probably within 500 feet of the contact surface. This surface is probably irregular in detail, but in general in the vicinity of the mine it is like a broad shoehorn steepening downward. The stock intrudes hornfelsic argillite and siltstone of member B of the Red Rose formation and a group of dyke rocks of which fine diorite is the most important.

The mine is almost entirely within a fine diorite dyke that is older than the stock. This diorite body is an elongate tongue-shaped pluton rising to the east

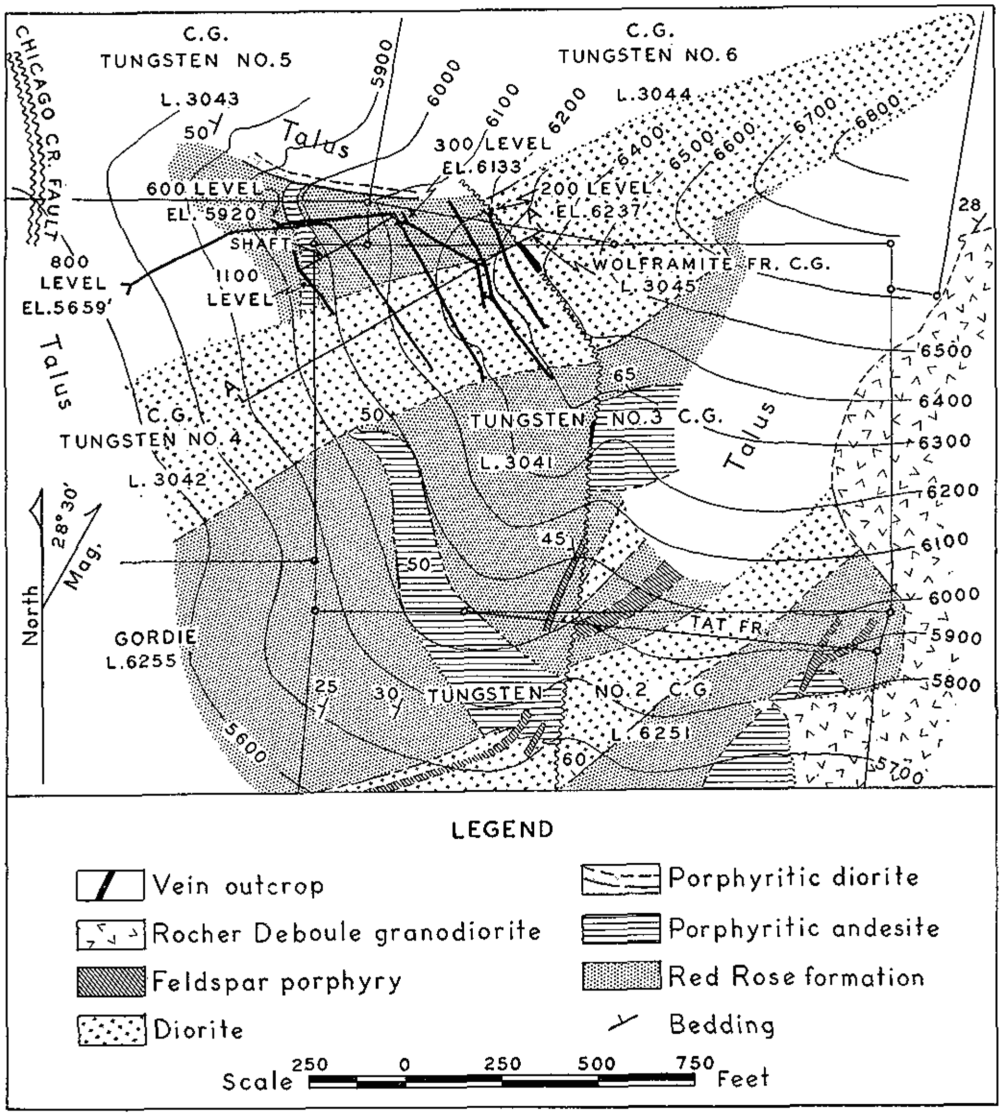


Figure 10. Geology in the vicinity of the Red Rose mine.

(*see* Figs. 10 and 11). It is 300 to 400 feet wide, at least 450 feet thick, and about 2,500 feet long on the surface. The " mine " diorite is the northern of three subparallel major bodies described as pre-granodiorite dykes (pp. 25–26). The middle body is cut by granodiorite at the head of Red Rose Creek. The diorite is a fine-grained, dark greenish-grey rock composed originally of about 65 per cent zoned labradorite and 30 per cent pale green hornblende with iron ores, sphene, and quartz. A small amount of the labradorite occurs as phenocrysts. The hornblende has been largely altered by thermal metamorphism to a mosaic of amphibole and biotite.

Related to the diorite is a porphyritic diorite that in places merges with the mine diorite on the north of this body, but does not seem as regular in outline, having numerous dyke off-shoots. The porphyritic diorite is formed of 40 per cent labradorite phenocrysts and 10 per cent hornblende phenocrysts in a matrix of the same minerals, plus biotite, quartz, and iron ores. It is a lighter coloured rock than the mine diorite because of the abundance of white labradorite phenocrysts.

Older than the diorites are porphyritic andesite dykes within the Red Rose formation that are judged to be related to the Brian Boru flows of similar composition (*see* pp. 22 and 26). They are dark grey aphanitic to fine-grained rocks with about 40 per cent light grey tabular andesine phenocrysts which may be gathered in groups. Original mafic phenocrysts form 2 to 5 per cent of the rock and are commonly altered to a felted mass of small biotite crystals. The matrix is composed of andesine-oligoclase and biotite with minor quartz and iron ores.

Younger than the diorites are feldspar porphyry dykes, mostly small in comparison with the diorite and porphyritic andesite (*see* Fig. 10). They are dark purplish-grey rocks composed of 20 to 25 per cent tabular andesine phenocrysts and about 5 per cent mafic phenocrysts, now a felted mass of biotite. The matrix is composed of feldspar laths, biotite, and minor quartz and iron ores. Commonly there is a flow structure. The feldspar porphyry is not always distinguishable from the porphyritic andesite in a small outcrop, but it is younger, commonly occurs in small dykes, and has fewer phenocrysts which are more angular and rarely grouped.

The youngest igneous rock is felsite that occurs as rare thin dykes, one of which follows the vein shear and cuts the vein. It is a middle greenish-grey aphanitic rock with somewhat conchoidal fracture, composed of a felted mass of oligoclase and hornblende laths with interstices filled with chlorite, biotite, quartz, and iron ores. Calcite occurs as a secondary mineral in dispersed large grains. Oligoclase forms about 55 per cent of the rock, hornblende 15 per cent, and matrix and secondary minerals the remainder. It is similar to dykes in the Rocher Deboule and Victoria mines and to the light brown-weathering felsites that are common late dykes in the stock (*see* pp. 35–36). The vein dyke in the Red Rose mine is commonly only 2 to 4 feet wide, but in the lowest level (1100) is 7 to 8 feet wide. It meets the footwall of the shear or vein in the north, follows it, crosses to the hangingwall, and eventually passes into the hangingwall in the south. The dyke is not continuous on any one level, for it may pinch out and begin again in echelon pattern.

The Rocher Deboule stock has thermally metamorphosed all older rocks. The metamorphism has resulted in a general growth of brown felted biotite, not only in the matrices of the older rocks, but also in phenocrysts of hornblende and even along the cleavage planes of plagioclase. The felsite dykes and the vein are younger than the granodiorite and are unaffected.

Structure

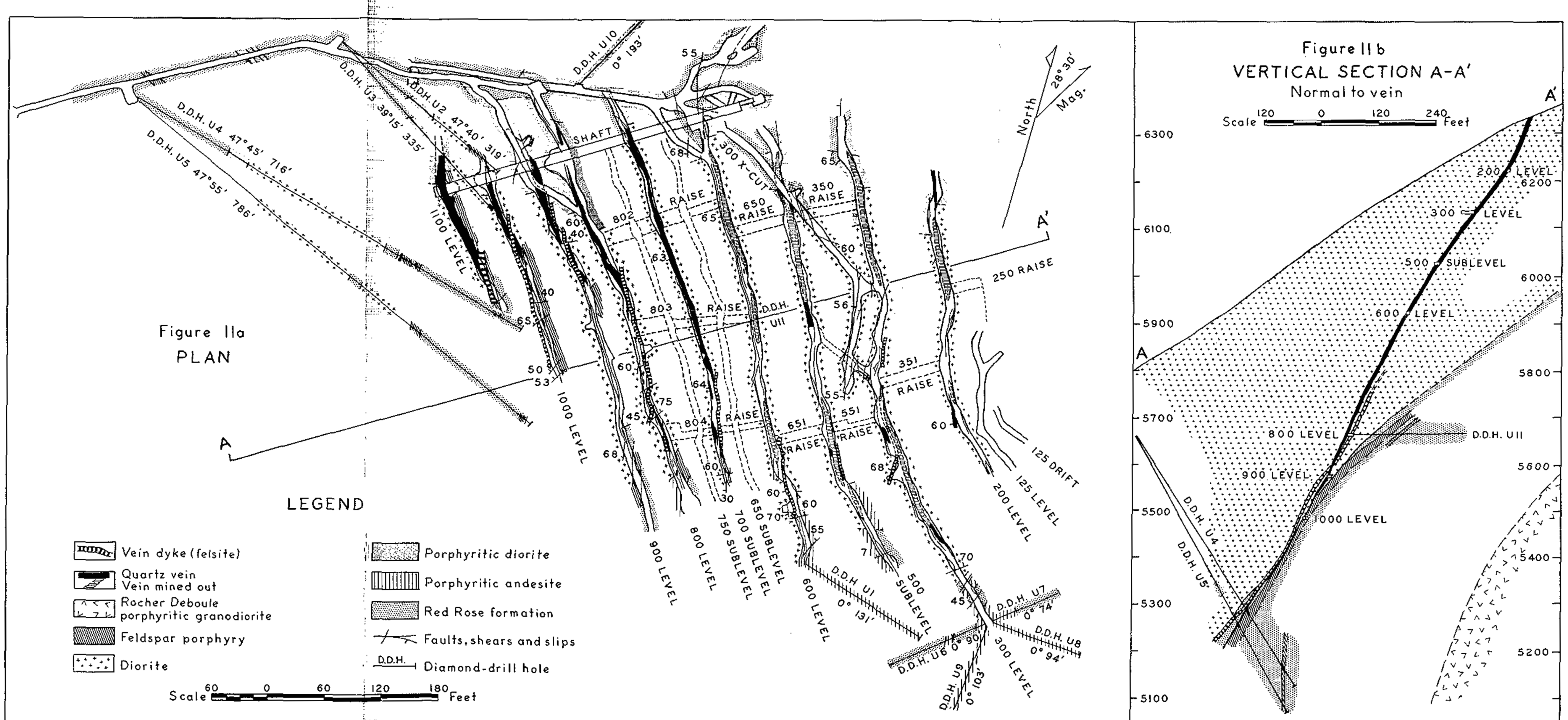
Bedding in the Red Rose formation is obscured in the vicinity of the mine by the thermal metamorphism. However, it strikes about north 15 degrees east and dips 30 to 50 degrees to the west on the western limb of a gentle anticline that is cut cleanly by the granodiorite intrusion. The bedding has an attitude very similar to that of the footwall of the mine diorite tongue and may have controlled the latter's shape.

The Chicago Creek fault passes about 250 feet west of the 800 level portal (*see* Figs. 2 and 10). It is a large normal fault that strikes north 10 degrees west, dips about 70 degrees westward, and has a dip-slip of 2,000 to 3,000 feet.

The Red Rose shear is a small fault that strikes north 30 to 40 degrees west and dips 60 to 65 degrees southwestward. It is well defined in the diorite tongue, but in the hornfels and porphyries it ramifies into a group of small tight fractures. The shear cannot be traced continuously on the surface from the ridge to the south slope, but it seems reasonably certain that the same zone is represented, if not the same actual shear. The movement on the shear is normal. Most slickensides observed by the writer rake 75 to 80 degrees to the northwest. If the two porphyritic andesite dykes on opposite sides of the shear are equivalent (*see* Fig. 11), the movement would be of the order of 300 to 400 feet. Such movement would bring a wide section of the mine diorite to the surface on the footwall, and such is the case. The precise relation between the shear and the Chicago Creek fault is unknown, but the shear is probably tributary to the fault. The general movement on the Red Rose shear and the Chicago Creek fault have both been east side up.

The Red Rose vein occupies the full width of the shear (4 to 8 feet) for 200 to 400 feet along strike and at least 1,100 feet down dip. The vein is of mining width and grade only within the mine diorite. The width may vary in a short distance, as from 9 feet to nothing within 40 feet on the 900 level. The vein is massive and unsheared and contains many small drusy cavities largely filled by euhedral quartz. The vein is formed largely of quartz with lesser amounts of feldspar, biotite, hornblende, ankerite, tourmaline, apatite, scheelite, ferberite, chalcopyrite, molybdenite, and uraninite. The vein has a pegmatitic appearance because of the many euhedral crystals of quartz, scheelite, ferberite, ankerite, and hornblende. The euhedral nature of some crystals is the result of vug-filling, and of others contemporaneous growth or replacement. In detail the quantity of scheelite and ferberite varies widely, but in general it is fairly uniform. Scheelite is the main ore mineral, and on the average constitutes about 1½ to 2 per cent of the vein. Some of the scheelite is a light green colour, but most is buff to cream coloured. All fluoresces a bluish-white. The green scheelite may be coloured by a somewhat larger than normal content of copper (within the range 0.1-1 and probably about 0.3 per cent). Ferberite is a minor component compared to scheelite. Judging by mill recovery in 1954 ferberite is about one-tenth as common as scheelite. The magnetic rejects of the mill are distinctly radioactive, owing to a small content of uraninite. The biggest concentrations of radioactive material, however, are erratically distributed with molybdenite in the wallrocks. These were noticed particularly on the 600 level. The Red Rose vein becomes richer in chalcopyrite with depth and on the lower levels contains some 2 per cent copper in that mineral. The chalcopyrite occurs particularly in the hangingwall shear in some fairly extensive lenses.

The vein contains two separate orebodies which are parallel and rake steeply to the northwest. Between these the shear has a more northerly strike and contains



RED ROSE MINE. PLAN AND SECTION

no vein filling. The length of barren shear is least on the 700 sublevel. The vein of the northwest orebody is as wide, long, and well mineralized on the 1100 level as anywhere in the mine, but the southeast orebody becomes thin and discontinuous below the 800 level. The orebodies are entirely within the mine diorite and adjacent porphyritic diorite. The footwall of the mine diorite dips at a shallower angle than the Red Rose shear, and at or shortly below the 1100 level the shear must pass entirely into the hornfels unless the diorite or the porphyritic diorite departs from the tongue-like shape.

The vein and the ore are limited to the diorite and porphyritic diorite for structural reasons. The shear is strong and well defined in the massive diorite, but degenerates into a group of ramifying slips in other rocks. Furthermore, the attitude of the shear determines whether it is vein-filled or not. Where the shear strikes north 35 to 40 degrees west in the diorite it is vein-filled, but where it strikes more to the north it is barren. In the hornfels the shear swings to a more northerly strike. Undoubtedly the northerly striking part of the shear was under compression, whereas the northwesterly striking part was more or less open. The vuggy nature of the vein confirms the existence of openings.

In summary, the most obvious ore controls are:—

(1) The footwall of the diorite tongue, and hence the limit of the ore, is probably controlled by bedding of the hornfels.

(2) The shear is well defined only in the massive fine-grained diorite and porphyritic diorite.

(3) The northwesterly striking section of the shear in the diorite is vein-filled, whereas the more northerly striking section is tight and contains no vein.

Ore Reserves

Reserves are not known in detail. The 1100 level was not mined. The vein on the 1000 level was about half mined and on the 800 and 900 levels about three-quarters mined. Above this there can be very little left. There is probably about 15,000 tons of ore of average grade above the 1100 level.

Possibilities of developing additional ore in the Red Rose shear cannot be ignored. The geometry of the mine diorite suggests that the present orebodies are completely developed and are nearly exhausted above the 1100 level, but in fact, nothing is known of the downward continuation of the northern orebody. Two deep diamond-drill holes (U_4 and U_5) drilled from the 800 level crosscut were barren, but intersected the shear well south of the possible continuation of the northern orebody. On the 1100 level this orebody is as wide as it is anywhere in the mine and is more extensive than it is on the 1000 level. The porphyritic diorite may continue to depth even though the mine diorite appears to be passing away from the shear. Moreover, the shear has not been explored along its continuation to the south, particularly where it intersects the other major diorite body.

[References: A. W. Davis, 1948, pp. 129–131; E. D. Kindle, 1954, pp. 55–57; *Minister of Mines, B.C.*, Ann. Repts., 1914, p. 190; 1916, p. 113; 1926, p. 126; 1951, pp. 111, 112; 1952, pp. 92, 93; 1953, p. 93; 1954, pp. 86–95; J. S. Stevenson, 1943, pp. 60–67; ———, 1947, pp. 433–464; A. Sutherland Brown, 1957, pp. 17–20.]

Rocher Deboule (5)

The Rocher Deboule mine is 5 miles south of South Hazelton near the head of Juniper Creek. It is reached by a road 8 miles long from Skeena Crossing, 11 miles southwest of South Hazelton. The road is currently (1958) blocked by slides 5 miles from Skeena Crossing.

Ownership

The mine is owned by Farwest Mining Limited (company office, 1075 Melville Street, Vancouver) which previously was called Farwest Tungsten Copper Mines Limited, Western Tungsten Copper Mines Limited, and originally Western Uranium Cobalt Mines Limited. The property consists of the following Crown-granted claims: Juniper (L. 2400), Balsum (L. 2401), Jack Pine (L. 2402), Timber Line (L. 2403), Iowa (L. 2404), Log Cabin (L. 2405), Balsum Fraction (L. 2406), Pie Fraction (L. 2407), Third Fraction (L. 2408), Joe Fraction (L. 533), and Last Chance (L. 3523). These claims are adjacent to a group of ten Crown-granted claims that is owned by the same company and forms the Victoria property.

History

The property was first located in 1910 by Sargent and Munroe of Hazelton and was acquired in 1911 by the Rocher Deboule Copper Company of Salt Lake City. Development of the property was done under lease by the Montana Continental Development Company, a company owned by principals of the other company. Ore was shipped from the upper part of No. 4 vein from April, 1915, until February, 1916, when the property reverted to its owners. Development work, which had been neglected, was then done on No. 2 and No. 4 veins and by 1917 a 3,100-foot crosscut (1201) was driven from the bottom of the valley of Juniper Creek to intersect all the known veins. Production in 1917 and 1918 was largely from No. 2 vein and was much less than in the two previous years, although the ore was of good grade. The mine was closed in October, 1918, because of a lack of developed ore and a drop in the price of copper.

The property was leased in 1929 by Aurimont Mines Limited, who mined and shipped some ore, and again in 1930 by Hazelton Copper Mines Limited, who did not.

The property remained inactive until 1950 when it was acquired by Western Uranium Cobalt Mines Limited (now Farwest Mining Limited). This company became interested in the Rocher Deboule mine initially as a means of access to its adjacent but difficultly accessible Victoria property, but immediately began to investigate the Rocher Deboule as a source of milling grade copper ore and as a prospect for uranium-cobalt ores. In 1950 a slide that blocked the portal of the 1200 level was cleared, the upper levels were cleaned out, and construction of a camp was begun. A 100-ton mill was put into operation in May, 1952, and shut down in November of that year, presumably because the grade was lower than expected. Part of the mill equipment was moved to the Red Rose mine which was operated by the same company. After the Red Rose mine was closed in 1954, equipment from the two mines has been largely sold.

Production

The recorded production of the Rocher Deboule mine is as follows:—

Year	Tons	Gold	Silver	Copper	Lead	Zinc
		Oz.	Oz.	Lb.	Lb.	Lb.
1915	17,000	1,418	21,893	2,788,000	......	......
1916	16,760	1,184	16,738	1,753,225	......	......
1917	2,889	781	7,987	714,871	......	......
1918	3,184	832	16,247	635,870	......	......
1929	72	10	2,972	6,120	751	7,219
1952	12,814	267	18,640	305,498	......	......
Total	52,719	4,492	84,477	6,203,584	751	7,219

Workings

The orebodies are contained in a group of parallel veins striking about north 75 degrees east and dipping northward at about 55 degrees into the mountain. The main veins are numbered 1 to 4 from south to north (*see* Fig. 12). The outcrop elevations of the main veins from Nos. 1 to 4 respectively are about 4,300, 4,500, 4,770, and 5,330 feet. A fifth vein, No. 2a, of similar strike but flatter dip occurs between No. 2 and No. 3. No. 2 and No. 4 veins are the only ones developed to any degree and are the ones from which all production has come.

These veins are developed by three main adit crosscut levels: 1200 (elev. 4,167 feet), 1000 (elev. 4,428 feet), and 300 (elev. 5,150 feet) (*see* Fig. 12, and Plate XIV). The upper part of No. 4 vein is developed by the 300 level and a winze leading down to the flooded 500 level, also the 100 adit level above. There is no development between the 500 level and the 950 level, which is a short adit drift at the outcrop of No. 2 vein. The lower part of No. 4 vein is reached by the long 1201 crosscut. No. 2 vein is developed by long drifts on the 1200 and 1000 levels and three small sublevels, the 950, 1050, and 1300, the last of which is connected by winze to the 1200 level. The small No. 2a vein is reached by a crosscut on the 1000 level, and No. 3 vein is followed by a drift on the 1200 level. In all, there are over 5,200 feet of crosscuts, about 3,000 feet of drifts on No. 4 vein, 3,500 feet on No. 2 vein, and 1,000 feet on all other veins. The amount of vertical development is small relative to the horizontal.

Geology

The geology of the mine is apparently simple. The mine is on the western periphery of the northern dome of the Rocher Deboule stock. The western ends of the 1202 and 1002 drifts cross the contact into hornfelsic siltstones of the Red Rose formation (member B). In the mine the contact strikes north 50 degrees west and dips 63 degrees southwest. The main country rock is the typical porphyritic granodiorite of the stock (*see* pp. 27–29), but locally deuteric alteration along joints has removed the dark minerals (*see* later). Jointing is pronounced in at least four sets with average attitudes as follows:—

(1) Strike, N. 55° E.; dip, 55° S.E.
(2) Strike, N. 15° W.; dip, 65° W.
(3) Strike, N. 85° E.; dip, 5° N.
(4) Strike, N. 60° E.; dip, 65° N.W.

The last three joint sets conform fairly closely with the normal orthogonal joint system of the stock. No. 4 set is the one along which most of the deuteric alteration and quartz-hornblende pegmatitic veinlets occur. Both alteration and pegmatitic veinlets are particularly prominent on the footwall sides of the major veins.

Dykes are not abundant in the mine. Four main rock types are evident. The first forms the Rocher dyke, a fine-grained quartz-monzonite body 40 to 80 feet wide, that strikes north 10 degrees east and dips 52 degrees west on the average, but dips locally from 47 to 60 degrees. The dyke has chilled margins. The petrology is similar to that of the quartz-monzonite phase of the Rocher Deboule stock. The age relations with the veins and vein fractures are complicated. The dyke is offset by the veins in 1002 west and 1204 east 4 to 8 feet, but on 1202 west the dyke apparently offsets by dilation No. 4 vein and fracture. The fracture becomes obscure on entering the dyke in most places and vein materials within it are inconspicuous and assays very low. It is most probable that the dyke was intruded at an early stage of vein formation.

A second and possibly related rock type is dark grey fine-grained diorite. On the 1200 level a small dioritic dyke parallels the Juniper fault (*see* later) and about 400 feet south of 1203 drift a similar 15-foot-wide dyke strikes north 30 degrees east and dips 70 degrees northwestward.

A porphyritic andesite dyke 12 feet wide occurs in the hangingwall of No. 3 vein shear on the 1200 level. This rock resembles dykes related to the Brian Boru formation, although clearly it is much younger.

A fourth and very minor type is represented by a pale greenish-grey aphanitic dyke 2 feet wide, striking north 10 degrees west and dipping 50 degrees west. This is offset 16 feet by No. 2 vein fracture on the 1200 level, 450 feet west of the crosscut. A similar dyke with a similar attitude and a like offset occurs 240 feet west of the crosscut on the 1000 level.

The Juniper fault, striking north 57 degrees west and dipping 70 degrees southwestward, is the only significant fault in the mine. It is younger than the veins and a small granitoid dyke that it follows on the 1200 level. It offsets No. 2 vein 100 feet to the left, although drag indicates a right-hand movement. Slickensides indicate that the latest movement was horizontal, but a net slip with a large normal component and a small right-hand horizontal component would account for the apparent inconsistencies of drag and offset.

The veins occupy shears that are remarkably uniform in over-all attitude. The veins are complex and were formed by successive deposition along fissures or shears that moved repeatedly. As a result the veins are lenticular in shape and variable in detail. They may be negligible in tight shears, or be 4 to 8 feet wide with or without much brecciated and altered granodiorite. There is a variable amount of mineralization in the wallrocks.

Mineralogy

Three distinct stages of mineralization are apparent. J. D. Galloway (*Minister of Mines, B.C.*, Ann. Rept., 1914, p. 185) reported this tentatively in the first extensive report on the property. J. J. O'Neill (1919, pp. 11–14) and E. D. Kindle (1954, pp. 59–61) elaborated on the mineralogy and sequence.

The first stage is primarily pegmatitic in nature and includes as principal minerals hornblende and quartz with lesser feldspar, apatite, magnetite, scheelite, and molybdenite. The small amount of uraninite that is present may belong to this stage.

The second and main stage includes principally chalcopyrite, glassy quartz, arsenopyrite, cobaltite, safflorite, glaucodot, and pyrrhotite.

The third stage includes principally milky quartz, tetrahedrite, sphalerite, galena, pyrite, and possibly chalcocite. Gangue minerals filling combs of quartz include siderite and calcite.

Secondary minerals include malachite, erythrite, limonite, and possibly chalcocite.

The precious metals appear to be distributed amongst several minerals, but principally the iron-cobalt sulpharsenides and arsenides, tetrahedrite, and chalcopyrite. The ore shipped in 1917 and 1918 was substantially higher in gold and silver than was ore shipped in previous years. The 1929 production was moderately high in gold, very high (41.3 oz. per ton) in silver, and contained lead and zinc. These shipments came principally from No. 2 vein which contains a higher percentage of third stage mineralization than No. 4. It seems that silver and possibly gold is preferentially concentrated in the third stage minerals.

Vein Shears

The orientation of the vein shears is relatively uniform as the following table shows:—

Vein No.	Strike		Dip	
	Average	Local Variation	Average	Local Variation
1	N. 60° E.	....	55° N.	....
2	N. 72° E.	59–83	51° N.	38–70
2a	N. 82° E.	....	36° N.	....
3	N. 74° E.	....	55° N.	....
4	N. 77° E.	65–83	53° N.	46–65

The vein shears follow the radial joints related to the cooling history of the stock.

Movement on the shears has been repeated, as is shown by the braided, lenticular, lensoid, and crosscutting nature of the vein fillings. The last movement on the shears was horizontal, judging by small slickensides which are widely distributed. However, indications of net movement are inconsistent. The shears look as if they might represent considerable movement, but offsets are slight. Small dykes on 1202 and 1002 drifts are offset 16 to 18 feet to the left by the vein shear. The Rocher dyke dips parallel to these dykes and on 1002 drift is offset about 8 feet to the left; on 1202 its relations with the main shear are not seen. The hornfelsic contact which has an apparently similar dip is not offset on 1002 and is offset 14 feet to the right on 1202. These separations might result from rotation, relatively large dip-slip, or even dyke intrusion at differing periods after initial movement. The most probable explanation is that a relatively large dip-slip is combined with a smaller left-hand strike-slip.

Vein Descriptions

No. 1 vein is followed by a drift for 50 feet on the 1200 level and is exposed in the rock slide on the surface. On the 1200 level it is a 2-foot wide breccia cemented by calcite with traces of chalcopyrite. On the surface it is better mineralized with chalcopyrite in hornblende and quartz. Backs are about 180 feet above the crosscut, but near the hornfels contact would be more than 250 feet. Deep blocky talus covers most of the exposure.

No. 2 vein is developed chiefly by the 1200 and 1000 levels, but there are several additional small workings including a winze and small drift below the 1200 level (*see* Figs. 12 and 13). Most of the ore mined in 1952 apparently came from stopes above the 1000 level on No. 2 vein. On the 1200 level east of the Juniper fault the vein consists of lenses of crushed rock about 2 feet wide, cemented with quartz and with some arsenopyrite, pyrite, chalcopyrite, and malachite, that alternate with tight fractures. West of the fault to about 150 feet beyond the Rocher dyke the shear is relatively tight and contains some crushed lenses 1 to 3 feet wide, but rarely more than 1 foot of vein matter, mostly of the third stage of mineralization. Sulphide minerals are mostly sphalerite, tetrahedrite, chalcopyrite, galena, and pyrite with comb fillings of siderite. From this point which is 120 feet short of the winze to 250 feet beyond the winze, the vein is relatively wide (1 to 6 feet) and is well mineralized with chalcopyrite, cobalt sulpharsenides, pyrrhotite, tetrahedrite, and occasional nests of scheelite. On the 1000 level more of the hornblendic ores occur. The eastern 300 feet of the vein is 2 to 5 feet wide with much hornblende-chalcopyrite ore. For 900 feet from this zone to the hornfels contact

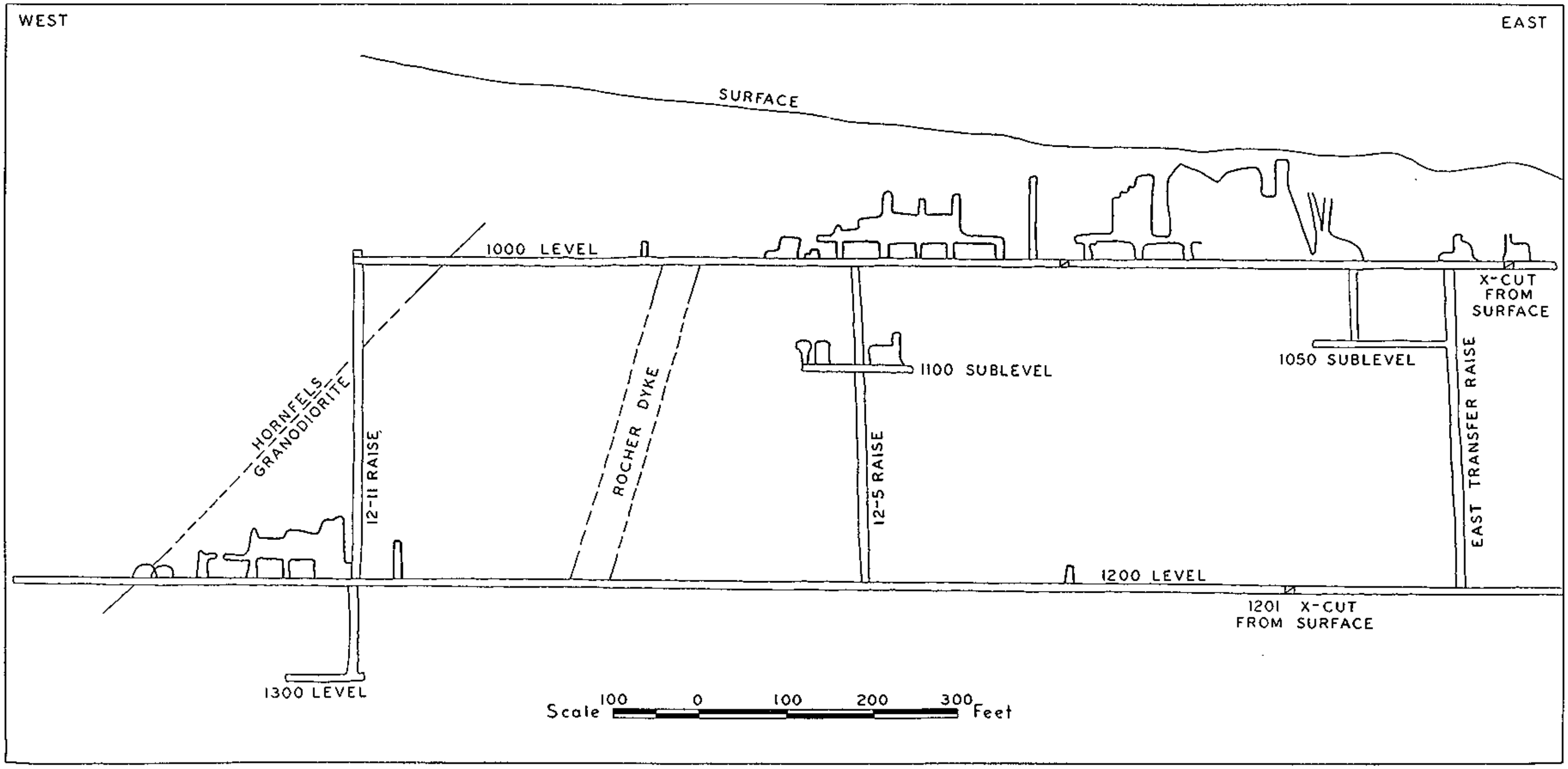


Figure 13. Rocher Deboule mine stope outline in the plane of No. 2 vein.

it is mostly mineralized, except for the Rocher dyke. In this distance the vein is 1 to rarely as much as 3 feet wide and generally the mineralization is of the chalcopyrite-hornblende type. Throughout No. 2 vein, in areas of hornblende-chalcopyrite ore, the walls contain small but consistent amounts of copper, possibly as chalcocite.

No. 2a vein is exposed only on the 1000 level and was not seen by the writer. It is not the same as No. 3 vein as was once believed.

No. 3 vein is exposed only by 600 feet of drift on the 1200 level. Here it is chiefly a fault with a 12-foot-wide porphyritic andesite dyke on the hangingwall and containing very little quartz and calcite vein matter.

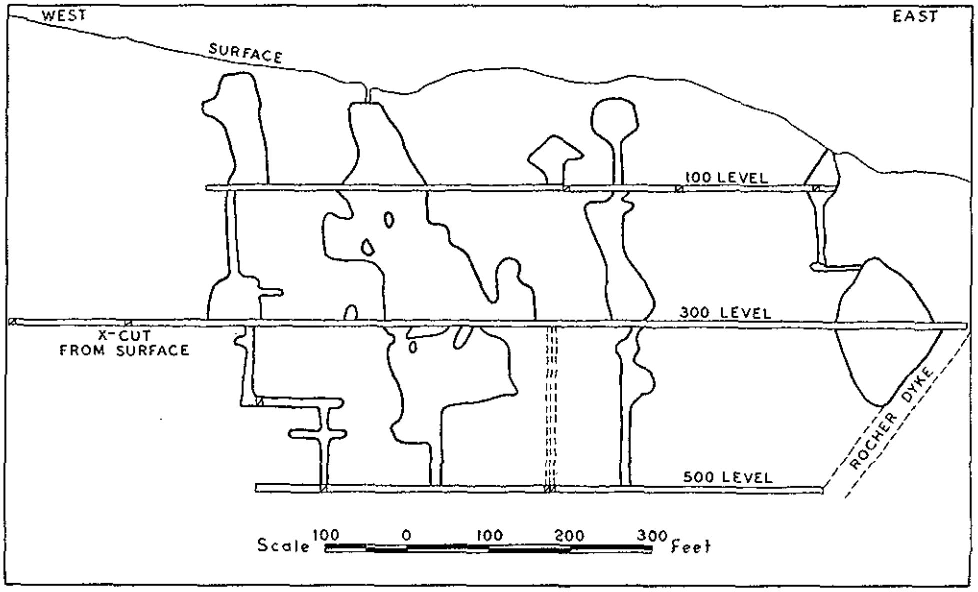


Figure 14. Rocher Deboule mine stope outline in the plane of No. 4 vein.

No. 4 vein is developed by the 100, 300, 500, and 1200 levels, but cannot now be seen very well as the 500 level is flooded, the 100 and 300 levels are nearly all timbered, and the vein is mined out in the better sections (*see* Figs. 12 and 14). On the 1200 level the vein consists either of barren shear or of pegmatitic hornblende-quartz-feldspar with almost no metallic minerals.

The upper part of No. 4 vein produced all the ore shipped in 1915 and 1916, and some of that shipped in 1917 and 1918. Descriptions in the Annual Reports for 1914–1918 indicate that there were four distinct oreshoots (*see* Fig. 14) which contained large quantities of chalcopyrite in hornblende, but that these shoots terminated abruptly with little disseminated mineralization between them. The late mineralization appears to have been insignificant and ore minerals other than chalcopyrite are scarcely mentioned. It is not clear whether there was any ore of milling grade on the 500 level, but there was very little of shipping grade.

Alteration of the granodiorite wallrocks is slight except for seemingly late magmatic or early hydrothermal alteration. This alteration involves a net removal of dark minerals adjacent to joints, giving the effect of bleaching, and in some places is balanced by deposition of hornblende with quartz and feldspar and rare tourmaline in veinlets within the joints and in larger amounts within the vein shears.

This alteration is related in distribution to the main vein systems and in intensity to value within the veins. The zone of bleaching and alteration is on the footwall side of the main veins, in joints that are subparallel in strike to the veins and mostly subparallel in dip. The zones of most intense alteration are those on 1001 crosscut and on 301 crosscut, both on the footwall of rich hornblendic orebodies. Small alteration zones occur on the footwall of No. 1 vein on 1201 crosscut and particularly on the surface, and slight zones on 1201 on the footwall of No. 2 vein and of No. 4 vein. However, the zone on 1201 crosscut adjacent to No. 3 vein is much wider than would be expected from the value of No. 3 vein as revealed in 1203 drift.

The alteration is apparently related to the pegmatitic stage of vein development. The hornblende and ferrous minerals have been subtracted from the walls and deposited in conduits including the main veins. The alteration is a good guide to orebodies because later ore minerals replaced the hornblendic veins preferentially.

Like the mine geology, the ore controls seem simple. The veins occur in fairly uniformly spaced parallel shears of small total movement. These shears appear to represent enlargements and extensions of joints related to the cooling of the stock. The occurrence of pegmatite in the veins and subparallel joints points to an early origin of the vein system. The mineralogy shows a passage from high temperature during the deposition of magnetite through moderately high temperature during the deposition of chalcopyrite and cobalt-iron sulpharsenides to the obviously later and cooler sphalerite-tetrahedrite mineralization. Kindle (1954, pp. 62–63) points out that the known orebodies occur within the outer 1,500-foot shell of the stock and that the temperature gradient may have been an imporant control in the deposition.

The better hornblendic veins seem to occur preferentially at slight northward bulges of the vein shears, particularly in the eastward side of the bulge. Possibly these parts were preferentially opened by movement at either the pegmatitic or chalcopyritic stage.

Ore Reserves

Estimates made during the period 1950–1952 of the ore reserves of the Rocher Deboule mine varied greatly. Holland reviewed the matter in the 1952 Annual Report of the Minister of Mines (pp. 91-92) as follows:—

" In 1951, A. L. Clark, the managing director and consulting engineer, estimated the indicated ore reserve in No. 2 vein at 200,000 tons, grading 4.1 per cent copper, 0.4 ounce gold, and 4 ounces of silver per ton. At that time no systematic sampling of the vein had been done. In November, 1951, Hill and Legg, consulting engineers of Vancouver, were retained by the company to report on the ore reserves. About 100 samples taken during the course of their examination indicated two orebodies on 1200 level lying east and west of the winze. The orebody east of the winze was considered to be 130 feet long and that west of the winze 147.5 feet. A mining width of 4 feet was assumed and that the ore has a dip length equal to its strike length. The reserve in these two shoots was calculated by them to be 11,050 tons. Hill and Legg sampled only the western 500 feet of vein on 1000 level and did not allow any ore on that level.

" On December 12th, 1951, N. N. Kohanowski, associate professor of mining geology at the University of North Dakota, submitted a report to the company. He took twelve samples and on No. 2 vein calculated a total of 315,000 tons of ' indicated and reasonably assured ' ore having a content of about 4 per cent copper. This estimate assumed ore to extend for 850 feet east of the winze on 1200 level, to extend as much as 350 feet below 1200 level, to extend to a height from 225 to

370 feet above 1000 level, and included a very large tonnage of ore in the sedimentary rocks extending as much as 500 feet beyond the granodiorite contact. On the basis of present knowledge, these assumptions are not warranted.

"In March, 1952, forty-one samples were taken on 1000 level, seven in 12-5w raise, five in 12-11w raise, and twenty-seven on 1200 level by J. E. Merrett and A. R. C. James, of the Department of Mines. These samples do not indicate any further oreshoots on 1200 level other than the two previously indicated by Hill and Legg near the winze. On 1000 level between the crosscut and the Rocher dyke, average assay content of the vein is as follows:—

Description	Width	Gold	Silver	Copper
	Ft.	Oz. per Ton	Oz. per Ton	Per Cent
For 350 feet west of the portal crosscut	2.4	0.06	14.3	4.4
For 120 feet on each side of 10-5 Raise	*2.34*	*0.12*	*4.5*	3.2
For 180 feet between 12-5w Raise and the Rocher dyke	1.25	0.04	3.5	3.6 "

Reasonable estimates of ore reserves are concerned entirely with No. 2 vein as no proven or probable ore can be allowed for No. 4 vein above the 300 level.

The company completed detailed sampling of No. 2 vein in May, 1952, assaying for copper only. Samples were cut well into the walls to include chalcocite and tetrahedrite suspected in the wallrocks. The grades calculated from this work for a 4-foot or greater mining width are slightly below those of Hill and Legg for the orebodies on 1202 drift; they are slightly above the grades of Merrett and James, recalculated to a 4-foot mining width for the orebodies on 1002 drift.

Whatever the ore reserves were in May, 1952, they were reduced by the 12,814 tons mined before the mine closed. From this tonnage 305,498 pounds of copper, 18,640 ounces of silver, and 267 ounces of gold were recovered. Nothing is recorded as to dilution or mill recovery. Figure 14 shows that most of the production was from stopes above 1002 drift with a small amount from stopes west of the winze on 1202 drift.

Possibilities

Prospecting possibilities remain in all the known veins of the Rocher Deboule mine. During the 1950–1952 operation no diamond drilling or exploratory driving were done. The known reserves are entirely within No. 2 vein. Further possibilities exist below the 1200 level near the hornfels contact.

No. 1 vein also offers possibilities, especially toward the hornfels contact where the backs are some 250 feet above the 1200 level. Alteration is fairly intense on the surface exposure in the rock chute between the portals of the 1200 and 1000 levels so that possibilities exist for hornblendic ore.

No. 3 vein may offer possibilities because of the intense alteration on the footwall side of the vein on the 1200 level. The vein is not very well mineralized in the drift, but it has not been explored elsewhere.

No. 4 vein is of interest because old reports indicate a possibility of milling-grade ore on the 500 level. Also, the 1200 and 500 levels are 800 feet apart on the dip of the vein, and the ground west of the Juniper fault toward the hornfels roof is of interest. Further possibilities exist west of the Rocher dyke on the 300 level.

[References: E. D. Kindle, 1954, pp. 57–63; *Minister of Mines, B.C.*, Ann. Repts., 1911, p. 80; 1912, pp. 113, 114; 1913, p. 107; 1914, pp. 185–188; 1915, p. 77; 1916, pp. 106–109; 1917, pp. 101, 102; 1918, pp. 111, 112; 1928, pp. 158, 159; 1929, p. 155; 1930, pp. 138, 139; 1950, p. 100; 1951, p. 110; 1952, pp. 86–92; J. J. O'Neill, 1919, pp. 7–14.]

Sultana (16)

This property is at the head of the south branch of Straw (Boulder) Creek on a bench below the ridge on the south side of the creek. The showings are reached by a trail 8 miles long that follows the creek from a point just south of the bridge on Highway 16. They are in the centre of the range about 10½ miles south of New Hazelton and at about 5,200 feet elevation.

The property was first described briefly in the Summary Report of the Geological Survey of Canada in 1910 as the Last Chance and Little Wonder, but was not mentioned in the British Columbia Minister of Mines Annual Reports until 1921 when it was called the Sultana. It has repeatedly changed hands, mostly by relocation. The most intensive investigation was in the period 1921 to 1923 and in 1956. In 1923 The Granby Consolidated Mining Smelting and Power Company Limited held an option, and in 1956 the property was relocated by J. W. Bryant and Bert Spisak for Canusa Mining Company Limited. These most recent claims were the Snowshoe Nos. 1 to 8 of which Nos. 1 to 4 were in good standing on December 31st, 1958. Most trenches on the property were dug prior to 1923. Granby diamond-drilled one short hole in 1923 and Canusa drilled several short holes in 1956.

The showings are in the porphyritic granodiorite of the Rocher Deboule stock near the centre of the south dome and probably about 1,500 feet below the eroded roof. Orthogonal jointing is pronounced, with joints striking about north 30 degrees west and dipping 70 degrees southwest and 30 degrees northeast.

The main showing consists of a shattered zone in the granodiorite that originally consisted of pyrite, chalcopyrite, tetrahedrite, and molybenite with some quartz, but is now much leached and oxidized. The zone trends about north 70 degrees east and is exposed over widths of 10 to 12 feet by two main trenches and one pit for over 100 feet. Beyond this length there is relatively little indication of mineralization; the main shattered zone may be covered by deep talus along strike, but in places it does not seem to be present. However, several hundred feet on strike to the east there is a zone with small veinlets containing traces of chalcopyrite and molybdenite on joint surfaces mostly oriented north 30 degrees west, and the same distance to the west on an exposed knoll there are some small shears with comb quartz trending subparallel to the main zone. The main showing consists of intersecting fractures, the chief of which strike north 60 degrees east and dip steeply south. In the easternmost trench in the main zone the mineralized body seems to be cut off below by a shear striking north 55 degrees east and dipping 15 degrees southeastward. Boulders of similar gossan occur up hill and against the apparent direction of ice flow from the outcrop.

Although the mineralized shatter zone is highly weathered and leached of pyrite it contains interesting amounts of metals. A chip sample across 12 feet in the eastern of the two main trenches assayed: Gold, 0.01 oz. per ton; silver, 18.1 oz. per ton; copper, 1.93 per cent; and a sample across 12 feet in the western trench assayed: Gold, 0.01 oz. per ton; silver, 14.0 oz. per ton; copper, 2.20 per cent.

Diamond drilling by Granby and Canusa was reportedly discouraging, having found little mineralization at shallow depths below the main shatter zone.

[References: *Geol. Surv., Canada,* Sum. Rept., 1910, p. 97; E. D. Kindle, 1954, pp. 77, 78; *Minister of Mines, B.C.,* Ann. Repts., 1921, pp. 100, 101; 1922, pp. 99, 100; 1923, p. 107.]

Three Hills (1)

This property consists of six claims located first by Alfred LeToile in 1951 and relocated by LeToile, D. R. Willemar, and E. H. Harbottle in 1955. The claims, Three Hills Nos. 1 to 6, are between South Hazelton and Skeena Crossing on the east side of Highway No. 16, 2¼ miles south of Seeley Lake.

The showings are about 1,000 feet southeast of the highway at about the same elevation (1,100 feet). The terrain is flat and drift-covered except for a number of rock drumlins on which the showings are found. The main showing consists of a small rock drumlin about 120 feet wide and about two or three times as long, that rises some 25 feet above the adjacent drift-covered area. This area has been largely cleared of moss and overburden, and a shallow trench cut out of the surficial rock across the centre of the drumlin. The trench strikes north 30 degrees west and is approximately at right angles to the trend of the drumlin. Other showings occur on adjacent, larger rock drumlins, but they have been less extensively exposed or developed.

The rocks are hornfelsic argillite and feldspar porphyry of the Hazelton group. They strike north 35 degrees east, parallel to the trend of the drumlins, and on the southeast dip 40 degrees northwest; elsewhere the dip is obscure. The rocks are fractured by many small joints striking north 75 to 90 degrees east and dipping about 60 degrees north. Some joints are filled with small stringers of quartz and chalcopyrite. Two chip samples each taken over 10 feet in the central, better-looking part of the trench assayed as follows:—

Chip Sample	Gold	Silver	Copper
		Per Cent	Per Cent
1	Trace	0.3	0.058
2	Trace	Trace	0.61

During 1955 and 1956 the property was under option to Silver Standard Mines Limited, which drilled some short diamond-drill holes and did some stripping.

[References: *Minister of Mines, B.C.*, Ann. Repts., 1955, p. 24; 1956, pp. 25, 26.]

Victoria (4)

The Victoria mine is on the northwestern slope of the Rocher Deboule Range, 4½ miles south of South Hazelton at 5,000 to 6,000 feet elevation. It is reached either by a good 3½-mile trail from the Comeau farm on Highway 16, 5 miles southwest of South Hazelton, or by a trail that follows the contour of the mountain from the upper workings of the Rocher Deboule mine.

Names applied to the mine have varied with ownership and grouping of the claims. The most appropriate name is Victoria, because not only is that the name of the first located claim and the original name of the property but all the underground workings are on the Victoria claim (L. 3303). Other names that have been applied to the mine are Hazelton View, New Hazelton Gold-Cobalt mines, and Aurimont Gold mines.

The Victoria property is owned by Farwest Mining Limited, successor to Western Uranium Cobalt Mines Limited (*see* p. 60) which was formed in 1949 to develop this property. The company owns the following Crown-granted claims that are properly part of the Victoria property and owns as well the adjacent Rocher Deboule property (*see* pp. 59–67): Victoria (L. 3303), Belle (L. 3304), View Fraction (L. 3305), Belle Fraction (L. 3306), Mammoth (L. 3307), Tiger (L. 3308), Homestake (L. 3309), Red Cross (L. 3310), Monoplane (L. 3313), and Bowl Fraction (L. 3315).

History

The Victoria was first mentioned in the 1909 Annual Report (p. 84). It was developed by New Hazelton Gold-Cobalt Mines, Limited, during 1917, who first shipped a carload of hand-sorted ore in 1918. The same company mined another carload in 1925 and shipped it in 1926. The successor company, Aurimont Mines Limited, mined and shipped another carload in 1928. Three small shipments were made in 1940 and 1941 by the then owner, R. C. McCorkell. Western Uranium acquired the property in 1949, cleaned out the workings, extended the No. 2 and 00 adits, and started the No. 3 adit, but shipped no ore.

Production has come entirely from the No. 1 vein on the Victoria claim, as follows:—

Year	Tons	Gold	Silver	Arsenic	Molybdenum	Cobalt	Zinc
		Oz. per Ton	Oz. per Ton	Per Cent	Per Cent	Per Cent	Per Cent
1918	26.6	1.24	(1)	8.98	0.96	1.18	(1)
1926	22.0	4.65	(1)	42.3	(1)	4.6	(1)
1928	23.0	6.25	(1)	37.9	3.4	3.76	(1)
1940	7.7	2.18	0.2	6.6	(1)	2.6	*Nil*
1941	7.3	2.02	0.2	6.1	(1)	1.4	0.6
1941	3.4	3.92	0.3	33.3	(1)	(1)	4.4
Total	90.0	326 oz.	......	44,560 lb.	2,100 lb.	4,918 lb.	......

[1] Not available.

The workings consist of five adits, one raise and sublevel, and a number of open cuts (*see* Fig. 15). All the underground workings are on No. 1 vein, the most northerly of three parallel veins which comprise the main showings of the property. Figure 15 is a plan of chain and compass surveys by Stevenson (Ann. Rept., 1949) and the writer. It shows the workings on No. 1 vein from the lowest adit, No. 3, at elevation 5,168 feet to the highest adit, No. 00, at about 5,900 feet, and No. 1 open cut on the ridge at about 6,100 feet. Open cuts No. 2 to No. 4 are further east on the serrated ridge top. Workings on No. 2 and No. 3 veins consist of a few open cuts.

Geology

The showings of importance are all within the Rocher Deboule stock adjacent to the western contact of the northern dome of porphyritic granodiorite. Hornfelsic greywackes and siltstones of the Red Rose formation, probably member A, outcrop immediately west of the portal of No. 3 adit. These strike nearly north and dip steeply westward, not greatly different from the contact surface.

Dykes are not abundant on the property but are quite prominent in the workings because dykes follow the same shears as No. 1 and No. 2 veins. The dykes are cut by the veins. There are three main types of dyke rock, each of which occurs also in the vicinity of the Rocher Deboule mine. Following the No. 1 vein shear is a dark grey, fine-grained diorite dyke that averages 2 to 3 feet wide in No. 1 adit and above, but thickens downward to nearly 20 feet wide in No. 3 adit. This dyke resembles one that follows the Juniper fault in the Rocher Deboule mine. A second type in the wall of No. 1 vein is an aphanitic light grey felsite with some feldspar and quartz phenocrysts. This dyke is seen in No. 1 adit where it is 12 to 15 feet wide, strikes northeastward and dips steeply southeastward. A third type follows the No. 2 vein shear. It is a feldspar porphyry 30 feet wide that strikes eastward and dips 60 degrees northward and is similar to the feldspar porphyry that follows No. 3 vein in the 1200 level of the Rocher Deboule mine.

Veins

The showings are in three parallel vein shears and one small cross-vein. The main vein shears strike about north 85 degrees east, and dip about 60 degrees northward. No. 1 vein is well exposed naturally or by workings from the contact at 5,150 feet to the crest of the ridge at 6,150 feet. It will be described in some detail. No. 2 vein is about 1,000 feet south of No. 1 and is exposed intermittently on the Belle Fraction and View Fraction claims between 5,400 and about 6,000 feet. It is of similar type. No. 3 vein is reportedly about 700 feet south of No. 2 vein and 1,000 feet north of No. 4 vein of the Rocher Deboule mine. The cross-vein is a small but interesting vein that strikes northward and dips about 50 degrees eastward. From the contact on surface, it dips into the granodiorite.

No. 1 vein is the only one adequately explored. Figure 15 shows all the workings on the vein. Stevenson (Ann. Rept., 1949, pp. 85–91) describes each working in detail, separately.

No. 1 vein shear strikes north 85 degrees east and dips 58 degrees north on the average. Variations in strike range from north 74 degrees east to south 73 degrees east and in dip from 45 to 65 degrees. Striations in the shear plane in No. 2 adit rake 60 degrees to the west in the plane of the shear. The shear cuts the fine dioritic dyke and offsets the felsite dyke in No. 1 adit 20 feet to the left. It is filled with a variable amount of vein matter, ranging in width from a thin smear to 2 feet, and is commonly less than a foot wide. Gouge and rubble may be up to 2 feet wide. One hundred feet from the portal of No. 1 adit there is an open fissure that, according to Galloway (Ann. Rept., 1917, p. 104), extends for about 100 feet above and below the drift.

The vein matter consists principally of cobalt-nickel sulpharsenides in hornblende gangue with glassy quartz and feldspar. Additional minerals include molybdenite, uraninite, apatite, sphene, allanite, and rarely scapolite. Secondary minerals include erythrite, which is sometimes crystalline, and a yellowish- or yellowish-green-fluorescing uranium mineral which is possibly autunite (*see* Kindle, 1954, p. 87). The cobalt-nickel sulpharsenides are complex and variable as Stevenson (Ann. Rept., 1949, p. 86) shows. They occur in discrete crystals within hornblende and in quartz-feldspar veinlets in the hornblende veins and as streaks and lenses of massive sulpharsenide minerals a few inches to a foot wide in the shear. The gold is contained in the sulpharsenides. The molybdenite and uraninite tend to occur erratically in the pegmatitic phases of the hornblende veins, but also occur in the walls. Commonly these minerals are associated.

Alteration of the wallrocks is minor, but in several places the granodiorite and fine diorite dyke have undergone patchy alteration to a sericite-quartz-carbonate rock.

A table of assays of samples and specimens from No. 1 vein follows. These are mostly (No. 1–38) repeated from Stevenson (Ann. Rept., 1949, p. 87) but include seven (K1–7) from Kindle (1954, pp. 86, 87) and three by the writer (B1–3). As Stevenson pointed out the sampling was not an attempt to delimit the ore, because most of the best ore had been removed in early mining. The sampling does give some idea of the widths, grades, and variability of the veins.

The Victoria veins form one system with those of the Rocher Deboule property. From the No. 1 vein of the latter mine there is a sequence of veins of similar orientation, spaced every 700 to 1,000 feet, to the No. 1 vein of the Victoria. Similar dykes are found along the vein shears, and the veins contain similar gangue and ore minerals. The mineralogy of the No. 1 vein of the Victoria is almost the same as the western end of No. 2 vein of the Rocher Deboule, but without the chalcopyrite.

[References: E. D. Kindle, 1954, pp. 84–89; *Minister of Mines, B.C.,* Ann. Repts., 1916, pp. 114, 115; 1917, pp. 103, 104; 1918, pp. 112, 113; 1925, p. 134; 1927, pp. 132, 133; 1928, p. 159; 1940, p. 76; 1941, p. 41; 1948, pp. 80–82; 1949, pp. 82–93; 1950, p. 99; J. J. O'Neill, 1919, pp. 20–23.]

ASSAYS OF SAMPLES FROM No. 1 VEIN*

Sample No.	Width of Vein Matter	Description	Gold	Silver	Cobalt	Uranium-oxide Equivalent†
	Inches	*No. 1 Adit*	Oz. per Ton	Oz. per Ton	Per Cent	
1	8	Hornblende, cobalt-nickel sulpharsenides and limonite	3.73	0.6	2.5	0.03
2	10	Hornblende, in footwall of Sample No. 1	0.01	*Nil*	‡	0.001
3	10	Hornblende, some disseminated cobalt-nickel sulpharsenides (nickel, 0.3 per cent)	1.04	0.4	1.9	0.01
4	8	Hornblende, a small amount of pegmatitic quartz and pink feldspar	0.11	*Nil*	‡	0.007
5	6	Gash vein of cobalt-nickel sulpharsenides 1 inch wide, extending for 4 feet into hangingwall of main vein	7.75	4.3	3.3	0.42
6*	4	Streak of cobalt-nickel sulpharsenides (nickel, 0.4 per cent)	6.04	0.8	3.2	§
7	8	Hornblende, some pink feldspar	0.10	Trace	‡	0.028
8	12	Hornblende, some pink feldspar	0.08	*Nil*	‡	0.25
9	18	Hornblende, some pink feldspar	0.14	*Nil*	‡	0.013
10	8	Hornblende, some pink feldspar	*Nil*	*Nil*	‡	0.14
11	10	Across a lens of pegmatitic quartz and calcite in hangingwall of hornblende vein matter	*Nil*	*Nil*	‡	0.008
12	8	Hornblende in footwall of Sample No. 11	0.01	*Nil*	‡	0.16
13	12	Silicified granodiorite in footwall of Sample No. 12	0.01	*Nil*	‡	0.004
14	10	Hornblende plus small amount of disseminated cobalt-nickel sulpharsenides, adjacent to pegmatitic quartz and calcite	0.20	0.2	0.4	0.37
15	12	Hornblende, some pink feldspar	0.02	*Nil*	‡	0.41
16	24	Hornblende, some pink feldspar	0.01	*Nil*	‡	0.19
17	—	Along 1 inch of pink feldspar in hornblende vein matter	Trace	*Nil*	‡	0.019
18	6	Along lens of oxidized vein matter 3 feet long	2.24	0.2	0.6	0.003
19	6	Across hornblende and cobalt-nickel sulpharsenides in floor of drift	*Nil*	*Nil*	0.3	0.011
20	2	Across gash veins of hornblende on south wall of drift	0.04	0.5	‡	0.003
21	4	Along streak of pink feldspar, quartz and disseminated cobalt sulpharsenides in hornblende vein	0.05	*Nil*	‡	0.017
22	2	Along gash veins of pink feldspar and hornblende in footwall granodiorite	0.01	*Nil*	‡	0.006
23	16	Typical hornblende vein matter	*Nil*	*Nil*	‡	0.003
24	24	Across vein where in dyke, includes quartz-feldspar stringers	Trace	*Nil*	‡	0.005
25	10	Across vein, hornblende plus pink feldspar	0.02	*Nil*	‡	0.006
26	10	Across vein in face, mostly pink feldspar and quartz	*Nil*	*Nil*	‡	0.003
		No. 00 Adit				
27	10	Across sheared dyke, vein only a narrow shear	Trace	*Nil*	‡	0.009
28	10	Hornblende plus considerable cobalt-nickel sulpharsenides (nickel, 0.2 per cent)	2.81	0.2	3.2	0.12
29	8	Hornblende plus considerable cobalt-nickel sulpharsenides (nickel, 0.4 per cent)	5.09	1.0	3.8	0.011
30	10	Across dyke, including vein-hornblende	0.01	*Nil*	‡	0.006
		No. 1 Showing				
31	-	Hornblende mineralization from along footwall	0.53	*Nil*	0.7	0.011
32	10	Across lens of quartz and feldspar in footwall	0.18	0.2	‡	0.003
33*	4	Hand specimen of cobalt-nickel sulpharsenides and hornblende vein matter found in bottom of cut; also contains molybdenum, 0.81 per cent; and nickel, 2.8 per cent	7.88	1.1	5.9	0.75
34	8	No. 3 showing, hornblende and cobalt-nickel sulpharsenides (nickel, 3.4 per cent)	1.75	0.2	1.9	0.16
35	30	Across full width of vein, including pegmatite and hornblende plus cobalt-nickel sulpharsenide clusters, at west end of cut	0.20	Trace	0.4	0.13

* Samples taken in 1949, except those marked with an asterisk, which were taken in 1940.

† Radioactivity of each sample, measured in the laboratory, is reported as "equivalent per cent U_3O_8" and may be due either to uranium or thorium. However, spectrochemical analyses of representative samples from the Victoria indicate that on this property the radioactive element is uranium.

‡ Less than 0.03 per cent.

§ Not determined.

ASSAYS OF SAMPLES FROM No. 1 VEIN*—*Continued*

Sample No.	Width of Vein Matter	Description	Gold	Silver	Cobalt	Uranium-oxide Equivalent†
	Inches	*No. 1 Showing*—Continued	Oz. per Ton	Oz. per Ton	Per Cent	
36	4	Across lens of pegmatite quartz and feldspar 2 feet long	0.17	*Nil*	0.5	0.10
37	16	Hornblende and pegmatitic quartz and feldspar, at east end of cut	0.73	*Nil*	0.5	0.04
38*	4	Across rib of cobalt-nickel sulpharsenides exposed in 1940 easterly over ridge from Showing No. 4 and containing molybdenum, 0.9 per cent, and nickel, 4 per cent	5.66	2.9	2.4	§
		No. 3 Adit				
K1	20	Subsidiary parallel shear	1.64	*Nil*	1.08	*Nil*
K2	10	*Cross-vein*	2.21	*Nil*	0.83	0.71
		No. 2 Adit				
K3	12	Vein matter (nickel, 0.02 per cent)	2.04	0.26	1.81	*Nil*
K4	12	Altered granodiorite	Trace	Trace	*Nil*	*Nil*
		No. 0 Adit				
K5	14	Fissure zone	1.80	*Nil*	0.25	*Nil*
		No. 00 Adit				
K6	10	Hornblende, sulpharsenides (nickel, 0.02 per cent)	2.81	0.2	3.2	0.12
K7	11	Vein matter	1.74	*Nil*	0.44	*Nil*
		No. 2 Adit				
B1	16	Hornblende, quartz, and gouge with sulphides	6.06	0.7	2.72	0.0045
B2	18	Hornblende rock	0.05	Trace	0.11	0.0055
B3	9	Sheared hornblende vein with granodiorite	0.19	0.02	0.65	0.013

* Samples taken in 1949, except those marked with an asterisk, which were taken in 1940.

† Radioactivity of each sample, measured in the laboratory, is reported as "equivalent per cent U_3O_8" and may be due either to uranium or thorium. However, *spectrochemical analyses of representative samples from* the Victoria indicate that on this property the radioactive element is uranium.

§ Not determined.

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Plate I. View to southeast of Rocher Deboule Range from above upper Juniper Creek, Bulkley Valley left, Hudson Bay Mountain centre background. Red Rose mine, Chicago Creek, and Pangea faults marked. (B.C. 504:80.)

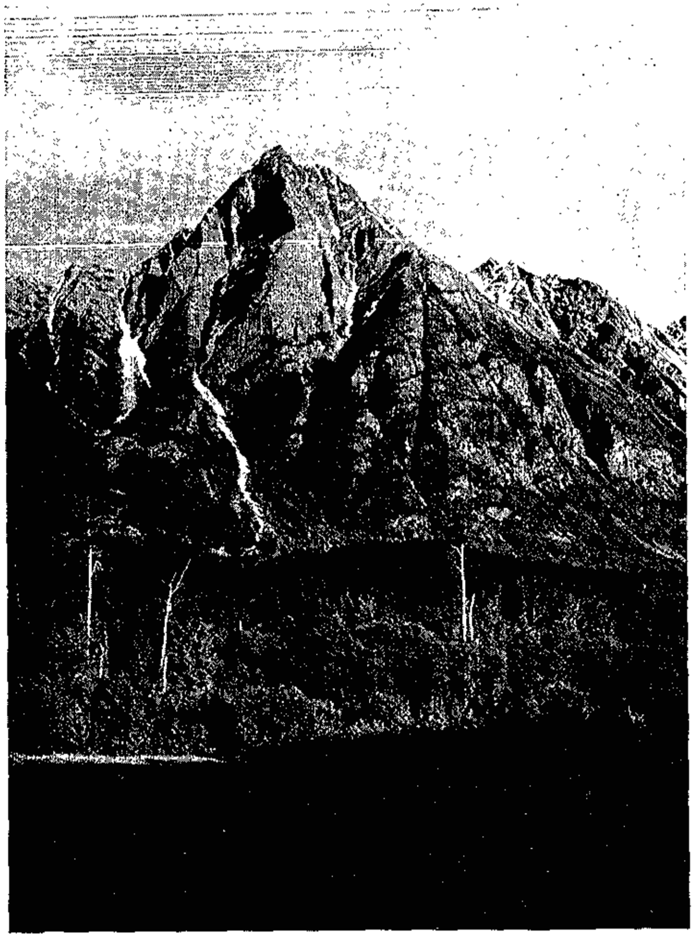


Plate II. Hagwilget Peak from near New Hazelton.


Plate III. Brian Boru Peak from the west.

Plate IV. View up the Bulkley River from below Moricetown. Island in foreground and low ridge in background formed of andesite in Tertiary sandstones and shale.

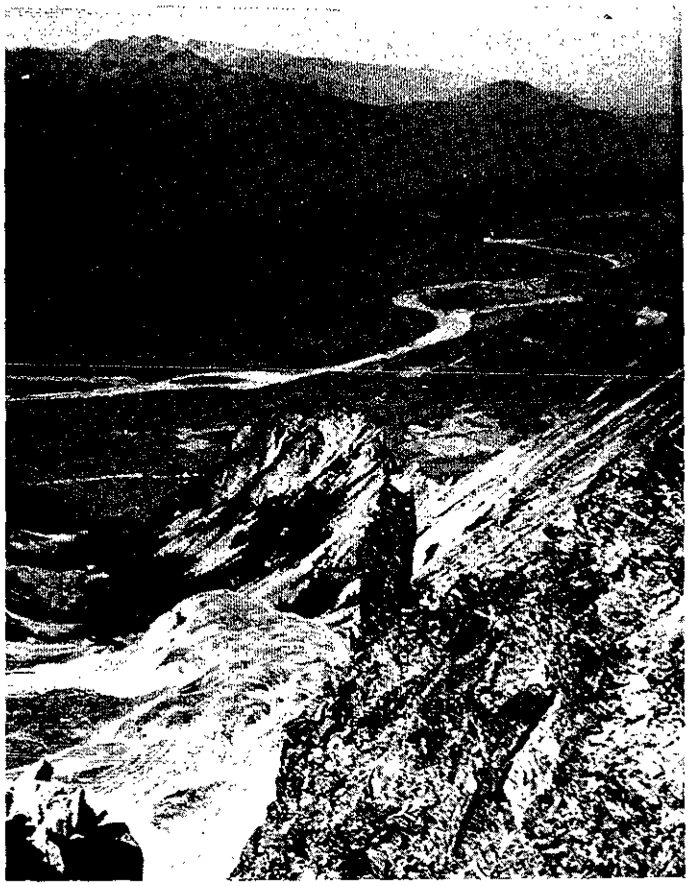


Plate V. Rock glacier on Chicago Creek. Hazelton is at confluence of Skeena and Bulkley Rivers in valley in right middle ground.

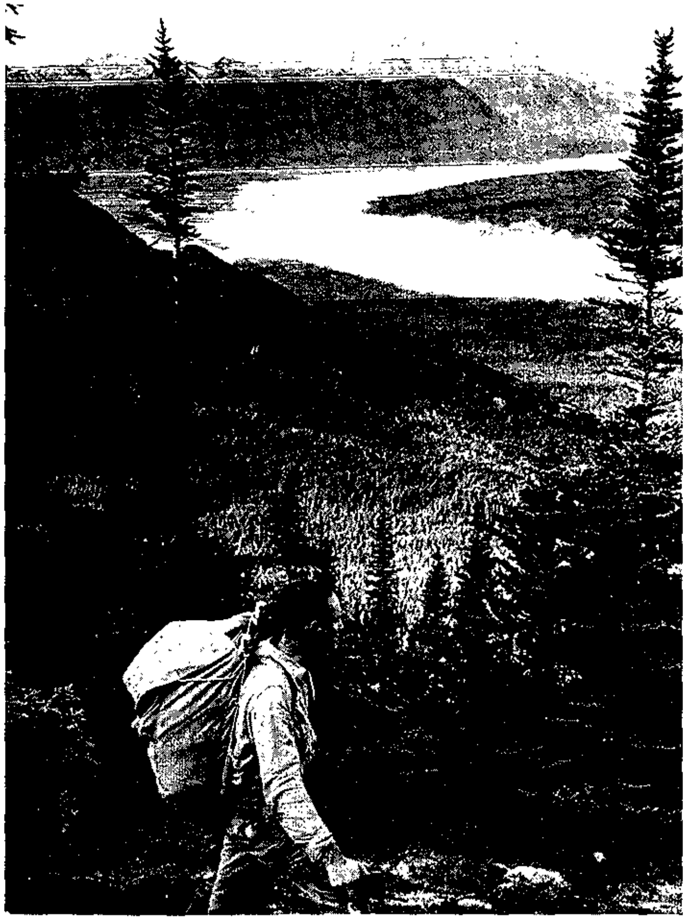


Plate VI. Looking west down the Skeena Valley to the Seven Sisters group from near the Victoria mine.

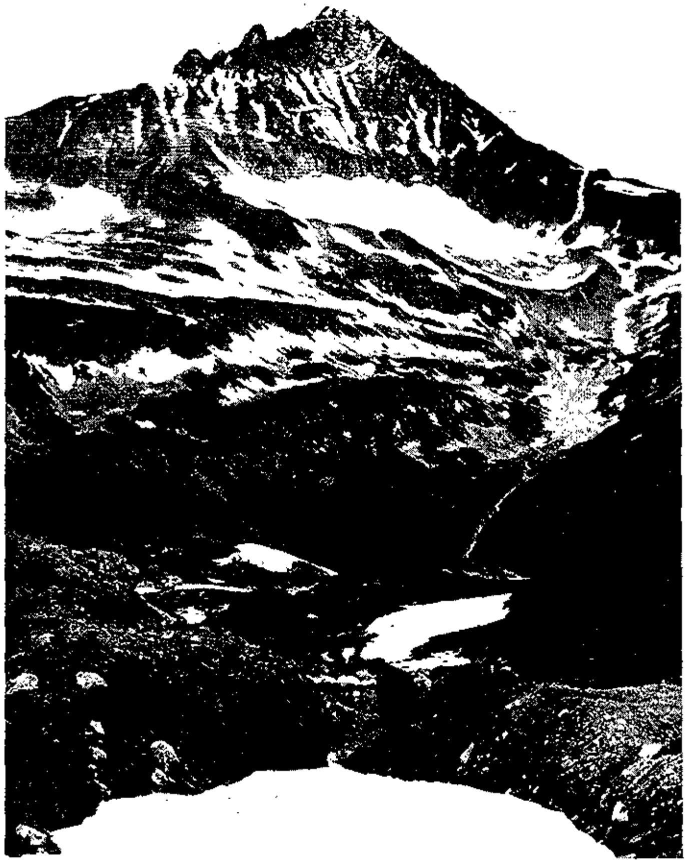


Plate VII. Tiltusha Peak from the east. Horizontal contact of granodiorite stock (just above snowfield) and horizontal joints control the minor topography in the cirque. Sultana showings in foreground.

Plate VIII. Cobble conglomerate of member D, Red Rose formation on Tiltusha Peak. Cobbles chiefly porphyritic andesite.

Plate IX. Coaly wood on bedding surface of poorly lithified Paleocene greywacke near Moricetown.

Plate X. Remnant glaciers at the head of Mudflat Creek. Black Prince prospect left above tarn lake.

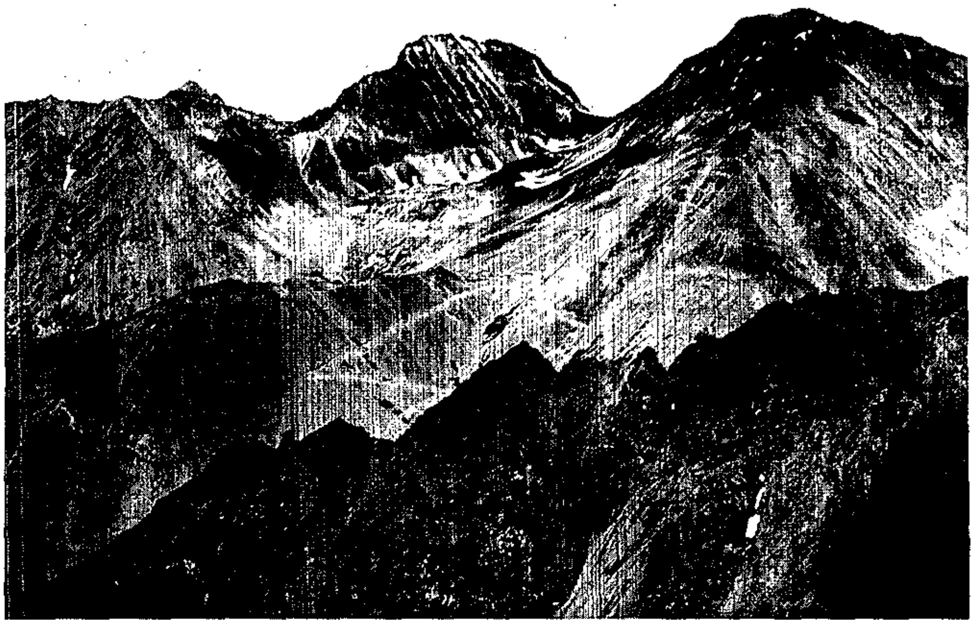


Plate XI. View of the Red Rose mine above saddle. Diorite tongue shows dark to right. Far peak formed of granodiorite, the remainder mostly hornfels.

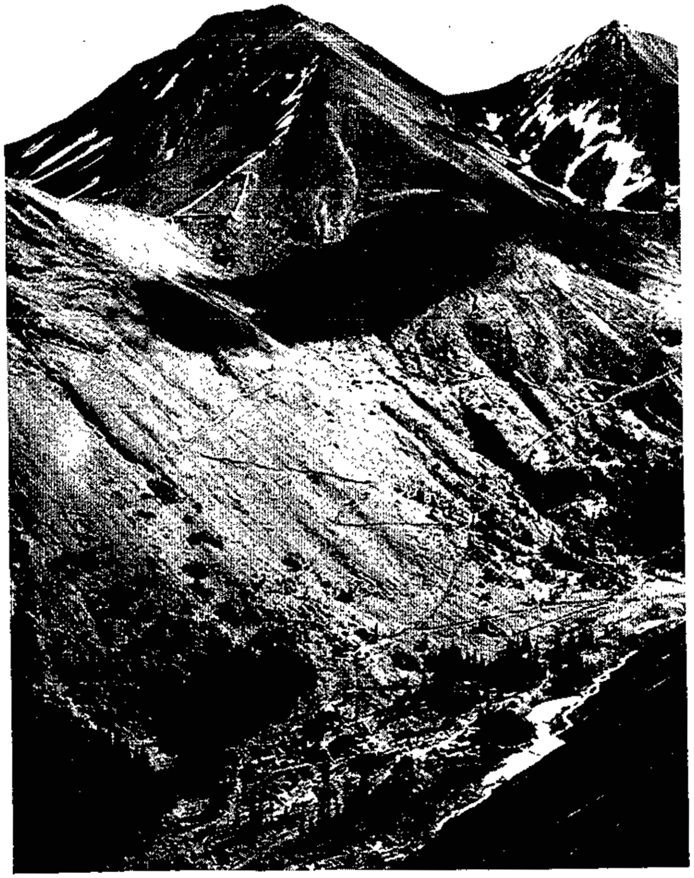


Plate XII. Red Rose mine and mill camps with connecting jeep-road and aerial tram (1953).

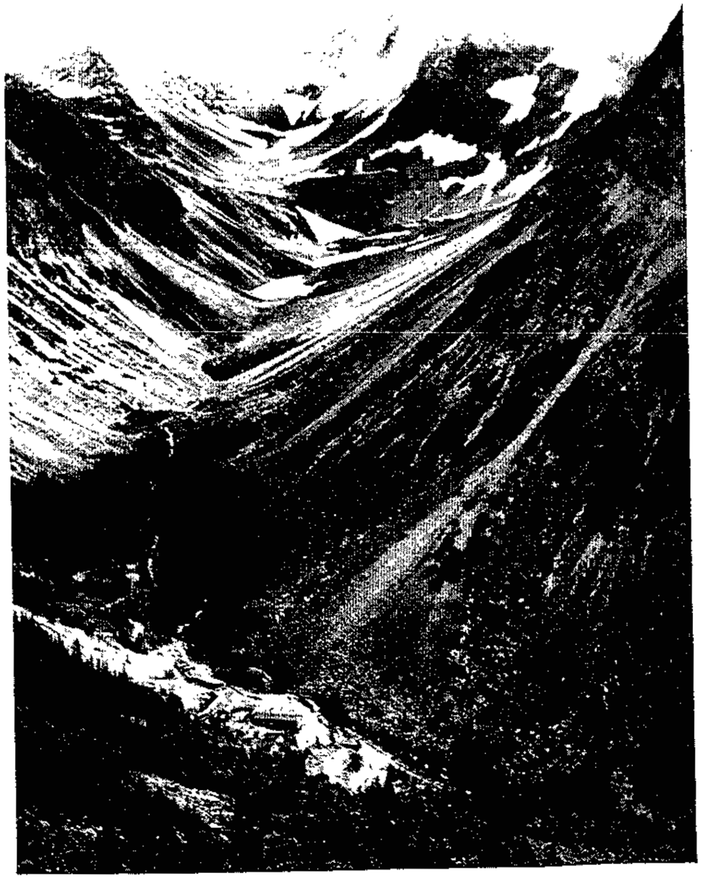


Plate XIII. Upper Juniper Creek showing talus slopes and Rocher Deboule mine camp.

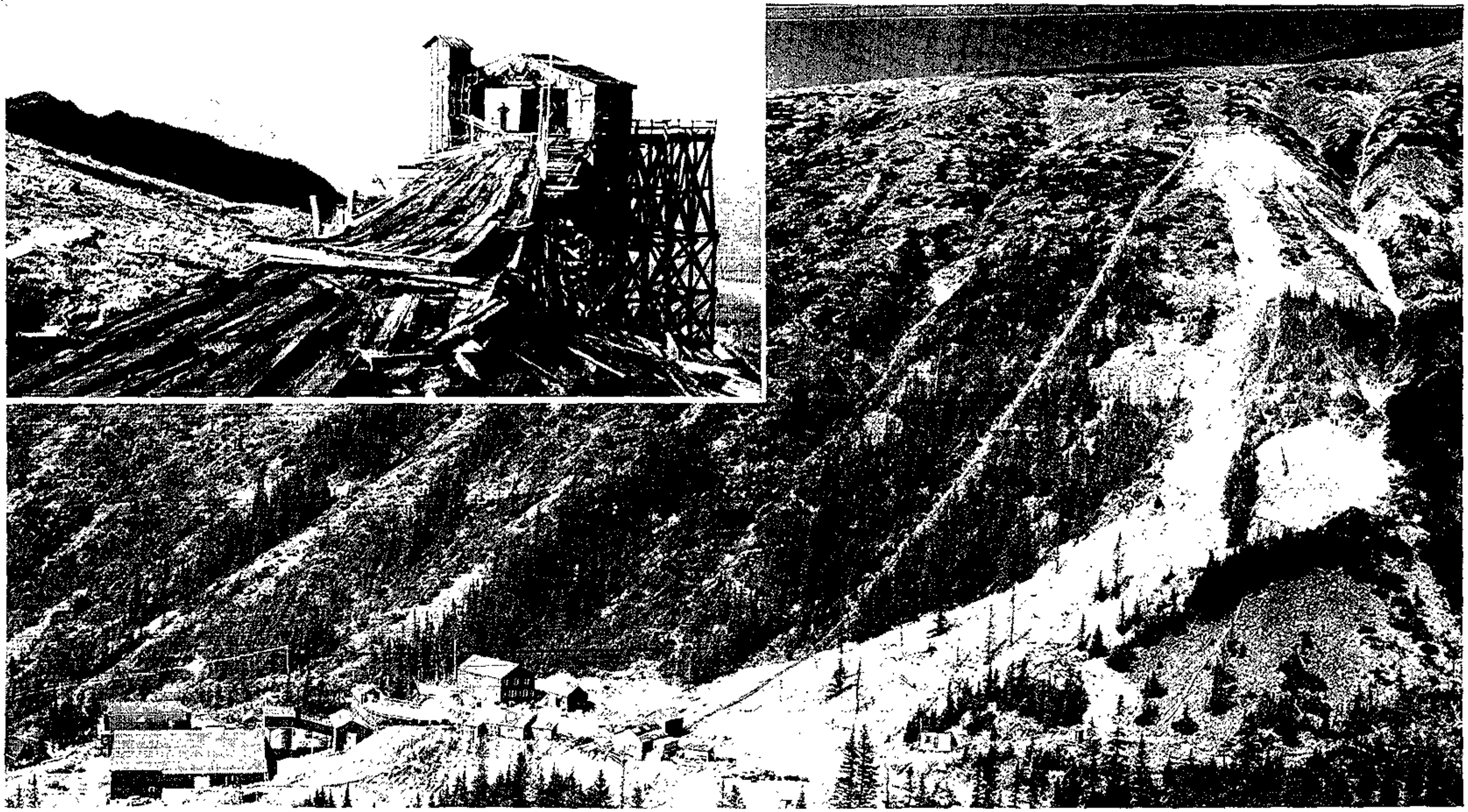
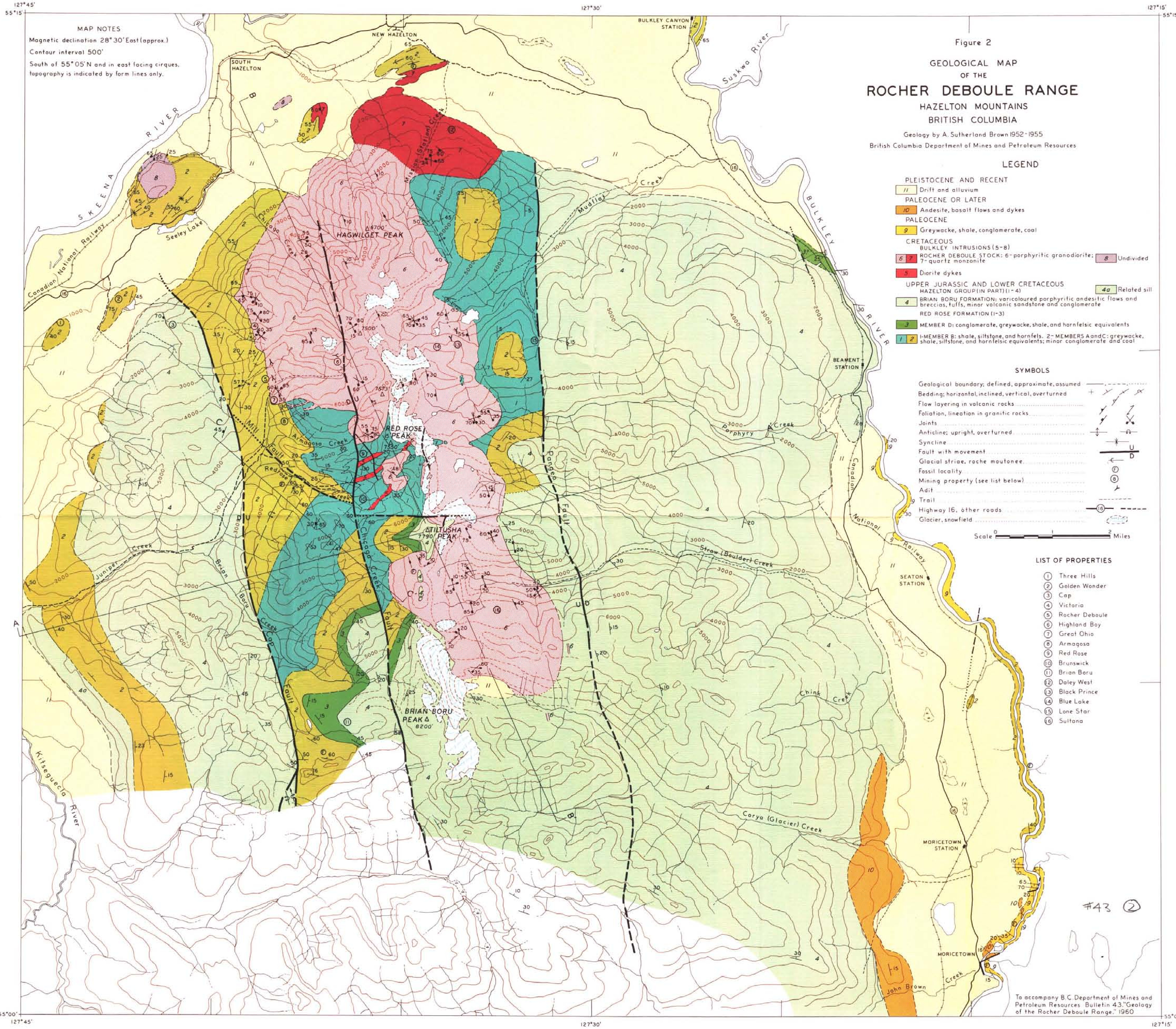


Plate XIV. Rocher Deboule mine and mill (1952). Portal of 1200 level behind shed at base of skip to 300 level. Rock slide which blocked main portal before 1951 was caused by water from upper workings. Insert: Head of old Rocher Deboule mine tram to Skeena Valley (1915–18).


MAP NOTES
Magnetic declination 28°30' East (approx.)
Contour interval 500'
South of 55°05'N and in east facing cirques, topography is indicated by form lines only.
Figure 2
GEOLOGICAL MAP
OF THE
ROCHER DEBOULE RANGE
HAZELTON MOUNTAINS
BRITISH COLUMBIA
Geology by A. Sutherland Brown 1952-1955
British Columbia Department of Mines and Petroleum Resources
LEGEND
PLEISTOCENE AND RECENT
11 Drift and alluvium
PALEOCENE OR LATER
10 Andesite, basalt flows and dykes
PALEOCENE
9 Greywacke, shale, conglomerate, coal
CRETACEOUS
BULKLEY INTRUSIONS (5-8)
6 7 ROCHER DEBOULE STOCK: 6-porphyritic granodiorite; 7-quartz monzonite
8 Undivided
5 Diorite dykes
UPPER JURASSIC AND LOWER CRETACEOUS
HAZELTON GROUP (IN PART) (1-4)
4a Related sill
4 BRIAN BORU FORMATION: varicoloured porphyritic andesitic flows and breccias, tuffs, minor volcanic sandstone and conglomerate
RED ROSE FORMATION (1-3)
3 MEMBER D: conglomerate, greywacke, shale, and hornfelsic equivalents
1 2 1-MEMBER B: shale, siltstone, and hornfels. 2-MEMBERS A and C: greywacke, shale, siltstone, and hornfelsic equivalents; minor conglomerate and coal
SYMBOLS
Geological boundary; defined, approximate, assumed
Bedding; horizontal, inclined, vertical, overturned
Flow layering in volcanic rocks
Foliation, lineation in granitic rocks
Joints
Anticline; upright, overturned
Syncline
Fault with movement
Glacial striae, roche moutonee
Fossil locality
Mining property (see list below)
Adit
Trail
Highway 16, other roads
Glacier, snowfield
Scale 0 1 2 Miles
LIST OF PROPERTIES
1 Three Hills
2 Golden Wonder
3 Cap
4 Victoria
5 Rocher Deboule
6 Highland Boy
7 Great Ohio
8 Armagosa
9 Red Rose
10 Brunswick
11 Brian Boru
12 Daley West
13 Black Prince
14 Blue Lake
15 Lone Star
16 Sultana
127°45'
127°30'
127°15'
55°15'
55°00'
NEW HAZELTON
SOUTH HAZELTON
BULKLEY CANYON STATION
SKEENA RIVER
Suskwa River
BULKLEY RIVER
Canadian National Railway
Seeley Lake
HAGWILGET PEAK
RED ROSE PEAK
TILTUSHA PEAK
BRIAN BORU PEAK
Mission (Station) Creek
Mudflat Creek
Chicago Creek
Armagosa Creek
Redrose Creek
Mill Fault
Porphyry Creek
Rango Fault
Chicago Creek Fault
Brian Boru Creek
Cap Fault
Juniper Creek
Straw (Boulder) Creek
Chink Creek
Corya (Glacier) Creek
Kitseguecla River
John Brown Creek
BEAMENT STATION
SEATON STATION
MORICETOWN STATION
MORICETOWN
#43 (2)
To accompany B.C. Department of Mines and Petroleum Resources Bulletin 43, "Geology of the Rocher Deboule Range." 1960

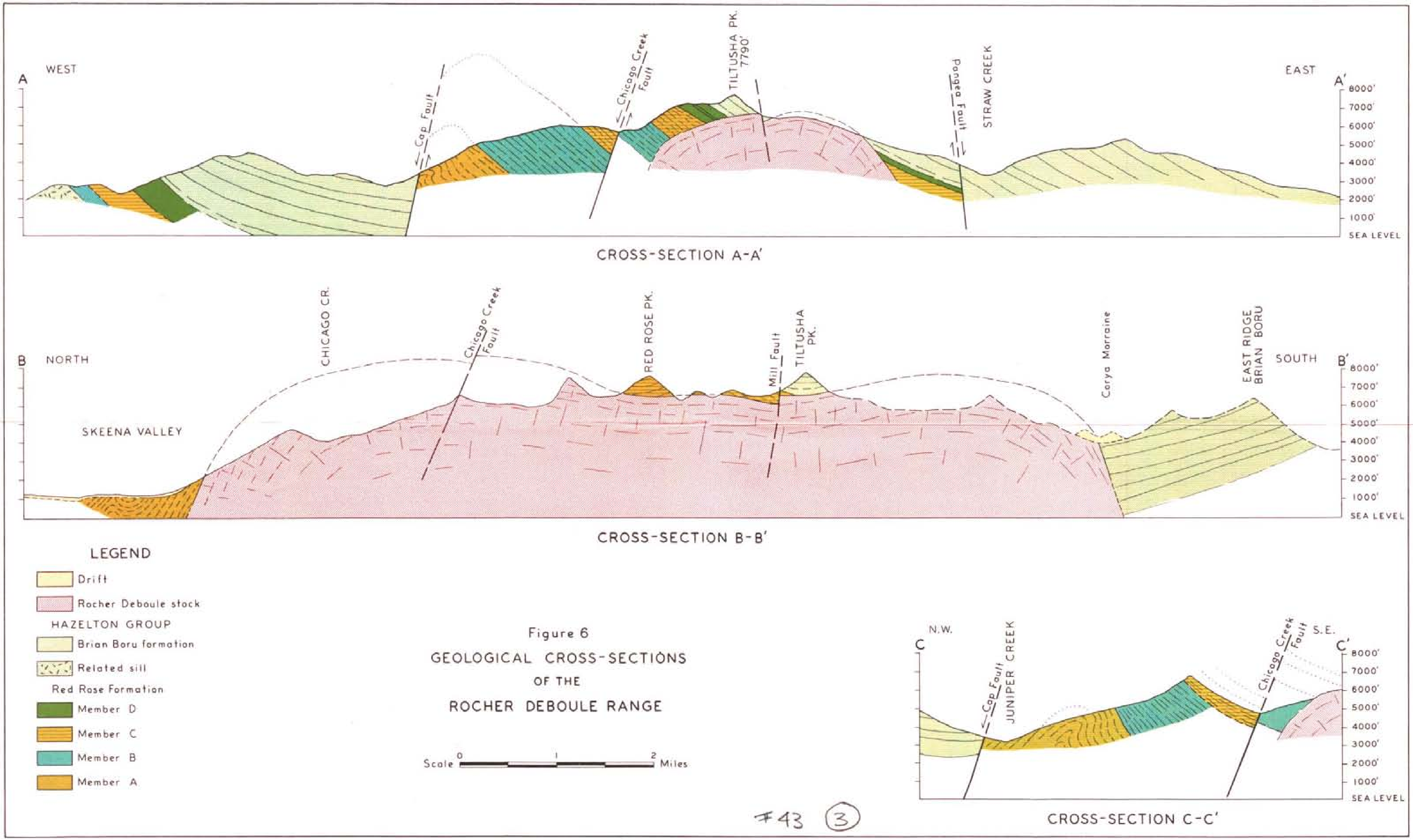


Figure 6
GEOLOGICAL CROSS-SECTIONS
OF THE
ROCHER DEBOULE RANGE

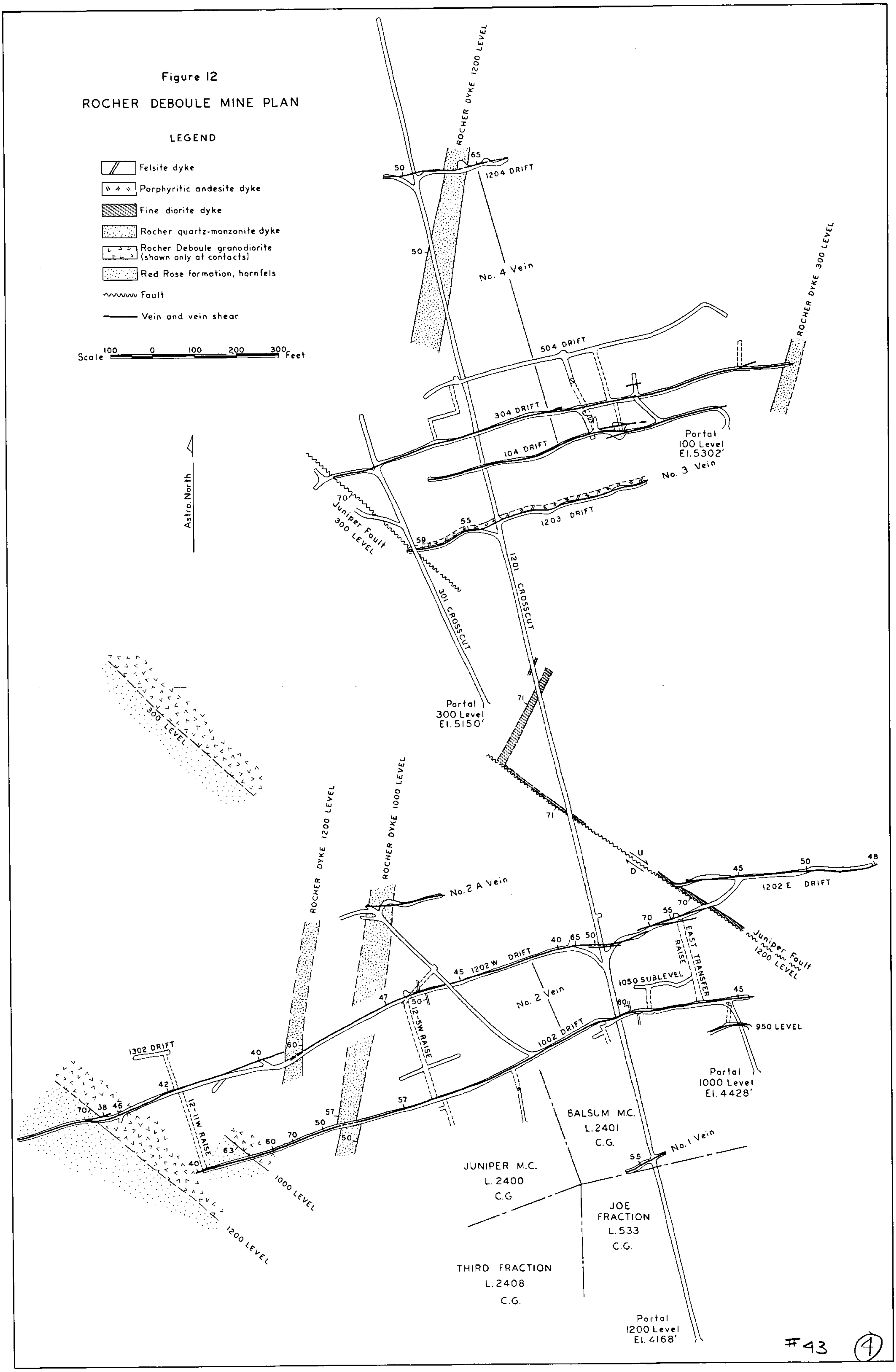


Figure 12
ROCHER DEBOULE MINE PLAN

#43 (4)

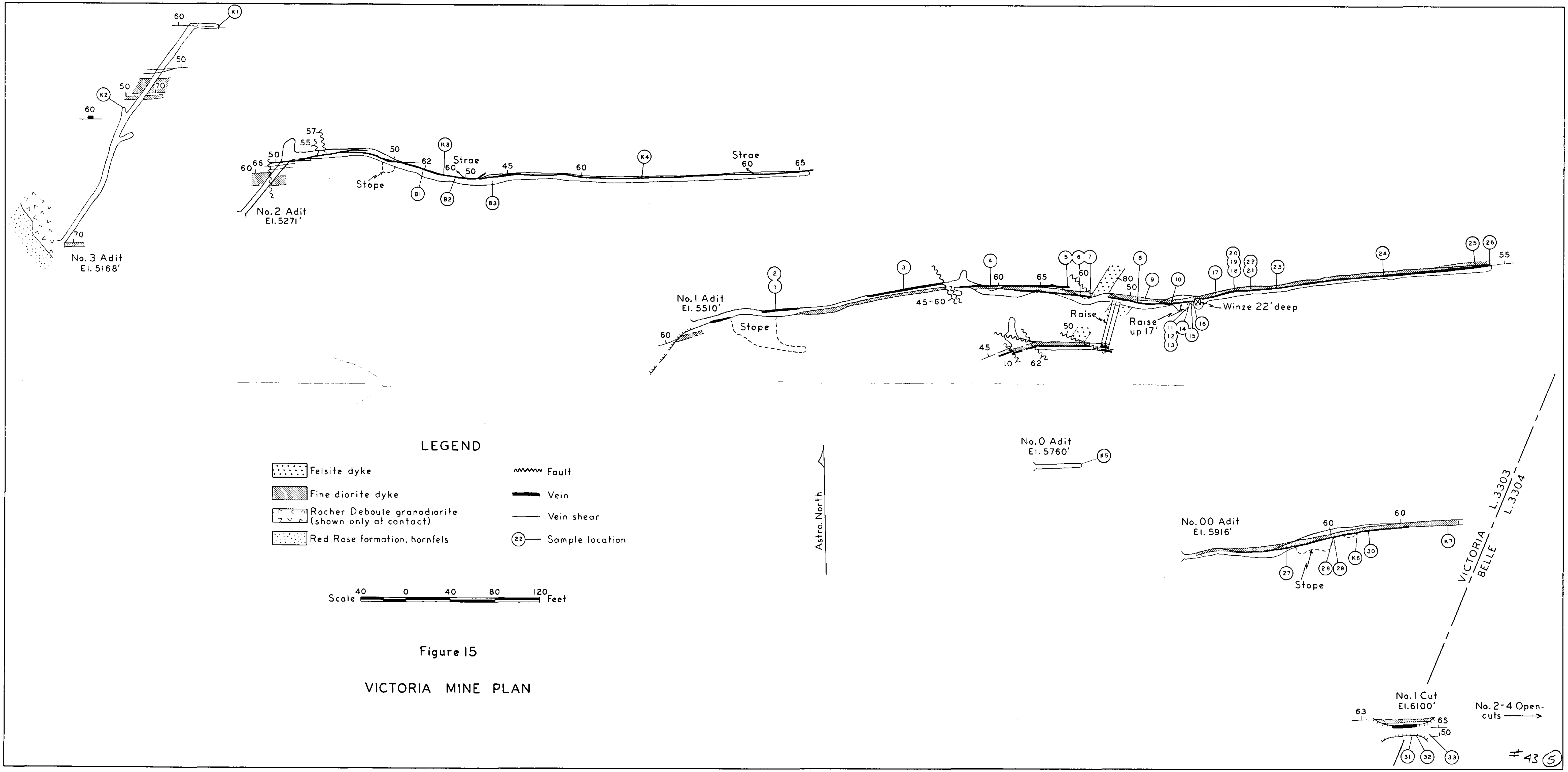


Figure 15

VICTORIA MINE PLAN